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FATIGUE AND DYNAMIC CREEP OF HIGH-STRENGTH STEELS

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ABSTRACT

A program was conducted to obtain detailed tensile, stress rupture and fatigue data on a series of high-strength steels. Data were obtained from D6AC, LaBelle HT, Thermold J, Vascojet 1000 and Peerless 56, heat treated to nominal ultimate strength of 280,000 psi.

Tests were conducted at room temperature and at elevated temperatures, the particular temperatures being selected according to the material. Maximum test temperature was 1000°F.

Dynamic creep data were obtained in conjunction with the fatigue tests.

This technical documentary report has been reviewed and is approved.

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I. INTRODUCTION

The designer of airborne systems is continually faced with the necessity of selecting the best materials and obtaining the maximum load-carrying efficiency from them. As these systems become more sophisticated, the designer is subjected to ever-increasing pressure to refine his procedures and to utilize the materials to higher proportions of their potential strength. Implicit in this process is an improved knowledge of the behavior of these materials and more specific information regarding their mechanical properties.

In the early history of airborne equipment, structures were designed with the intent that they not yield or fracture under conditions of maximum load. Since the knowledge of yield strength or ultimate strength of the materials used was rather meager, large safety factors were necessary if any degree of reliability was to be achieved. This, of course, led to inordinately heavy structures with consequently low cargo carrying capacity. Over the years the design process was refined and more detailed knowledge of tensile properties of the materials was gained, with the result that some degree of efficiency was attained even though the basis was essentially the same as originally. The use of these materials was pushed toward the region of higher stress levels, and consequently reduced safety factors, until these materials began to operate in a regime wherein failure by fatigue became important if not predominant. Thus, the aircraft industry became vitally interested in the subject of fatigue and in the fatigue properties of materials.

Further in the development of aircraft came an increase in temperatures, particularly with the advent of the turbine engine. This revealed another type of failure which resulted from steady loads applied for a long time at high temperatures. This type of failure is characterized by a gradual increase in dimension (creep) which, if sufficient time is involved, culminates in fracture (stress rupture). Either of these features may be serious, that of the stress rupture being obvious, and that of the creep being serious in cases wherein small changes in dimension are not permissible. As a result, many theoretical studies of fatigue, creep, stress rupture, and many tests, both on laboratory specimens and on structural components, have been conducted in order to establish acceptable design levels of loading under these conditions.

More recently, the designer has been faced with the problem of utilizing materials under combinations of the above conditions. Many cases exist in which a part is subjected to steady load at high temperature but with superimposed alternating loads. Ratios of alternating load to steady load can range from one extreme to the other. Only a few experimental studies have been made of this subject. Thus, there is a shortage of knowledge as to any possible interactions between these two types of loading wherein fatigue, creep, or stress rupture failures might be expected to occur.

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The project being reported here was designed to provide information on the behavior of a group of high-strength steels under various combinations of alternating stress, mean stress, and temperature. Tests were conducted on five steels having nominal ultimate strengths of 280,000 psi. Tests were conducted at stress ratios (stress ratio (A) $= \frac{\text{alternating stress}}{\text{mean stress}}$) of 0, 1, and ∞, with test temperatures ranging from room temperature to 1,000°F. Both notched and unnotched specimens were tested. Measurements of elongation versus time were made in all cases wherein cyclic stresses were present and in some cases wherein only steady stresses were present (stress rupture tests). In addition, simple tensile test data were obtained.

Detailed test data from all tests are presented in the Appendix. Other portions of the report, particularly the Results and Discussion Sections, summarize the results and indicate relationships of material response to the test variables.

II. SPECIMENS

Details of the sources and compositions of the five alloys involved in the test program are given in Table 1.

Heat treatment information is given in the tables of fatigue data, Tables 5 through 9 of the Appendix.

TABLE 1

TEST MATERIALS

Alloy	Supplier	Heat No.	C	Mn	Si	S	P	Cr	V	Ni	Mo
D6AC	Crucible	S9706	.44	.64	.24	.010	.006	1.03	.06	.50	1.01
LaBelle HT	Crucible	53428	.42	1.35	2.25	.015	.015	1.30	.27		.39
Thermold J	Universal-Cyclops	D21144	.48	.41	1.09	.007	.017	4.96	1.01	1.55	1.49
Vascojet 1000	Vanadium Alloys	31658	.40	.27	.88	.010	.016	4.97	.50		1.30
Peerless 56	Crucible	44526	.40	.58	1.07	.017	.015	3.21	.32		2.50

Heat treating procedures intended to produce 280,000 psi ultimate strength were obtained from the literature and from the respective suppliers

of the materials. Details of these procedures are given at the head of each table of data in the Appendix. Detailed tensile test data at the various temperatures are also to be found in the Appendix. Average values of room temperature tensile data for the unnotched specimens are, however, given in Table 2.

TABLE 2

AVERAGE ROOM TEMPERATURE TENSILE DATA (UNNOTCHED)

Material	0.2% Y.S.	U.T.S.	% Elongation	% R.A.
D6AC	237,000	270,000	5.3	38.3
LaBelle HT	237,000	291,000	7.6	40.5
Thermold J	275,000	338,000	5.7	25.4
Vascojet 1000	251,000	309,000	7.1	36.0
Peerless 56	252,000	297,000	5.5	27.2

As indicated in Table 2, ultimate strengths generally ranged somewhat above the intended value of 280,000 psi. This is particularly the case with Thermold J, for which the relation between ultimate strength and tempering temperature is quite steep in this range.

Microphotographs of each of the materials are shown in Figures 1 through 5.

Materials were purchased in the annealed condition in the form of one-half inch bar. Specimens were machined to the configurations shown in Figures 6-7. Notches are calculated to give a theoretical stress concentration of 3.0. The machining procedure consisted of rough machining to approximately .030-inch oversize, after which the specimens were heat treated. Following the heat treatment, specimens were ground to finish dimensions using a series of grinding passes of decreasing depth. Unnotched test sections were longitudinally machine-polished with a 600-grit belt. Notch root radii were polished by means of a rotating abrasive thread.

III. TEST EQUIPMENT

Fatigue tests were conducted on a Type PVQ Schenck vertical fatigue machine of six-ton capacity. The machine is shown in Figure 8. This machine was purchased new shortly before the initiation of the present testing program. It is a special machine in that the requirements for specimen alignment were held to closer tolerances than normal. The control system of

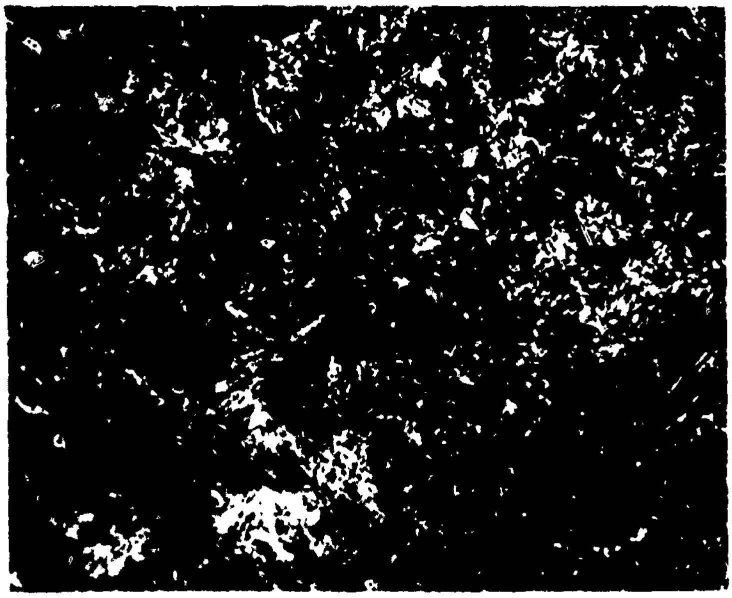

Figure 1. Micro-Photograph of D6AC-VILELLA'S REAGENT, 1000X

Figure 2. Micro-Photograph of LABELLE HT-VILELLA'S REAGENT, 1000X

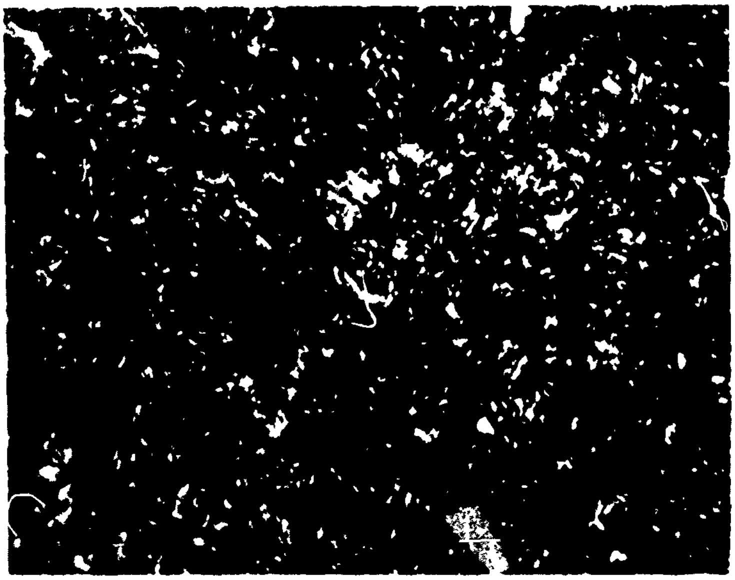

Figure 3. Micro-Photograph of THERMOLD J-VILELLA'S REAGENT, 1000X

Figure 4. Micro-Photograph of VASCOJET 1000-VILELLA'S REAGENT, 1000X

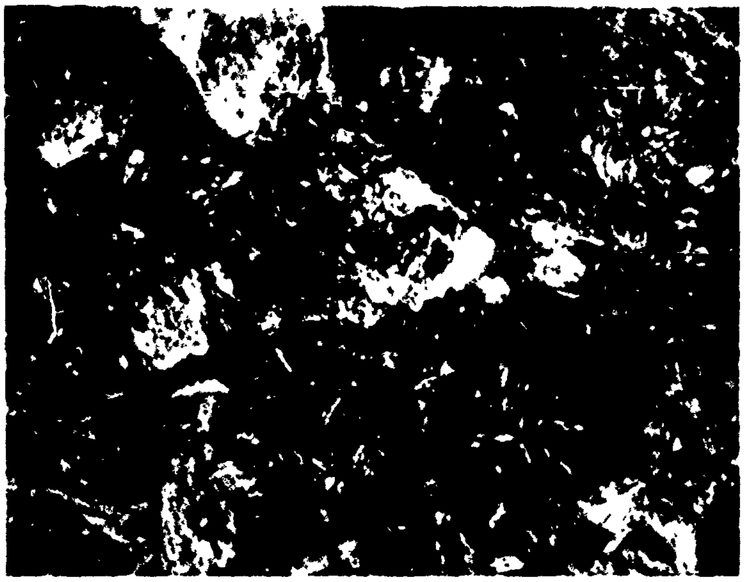

Figure 5. Micro-Photograph of PEERLESS 56-VILELLA'S REAGENT, 1000X

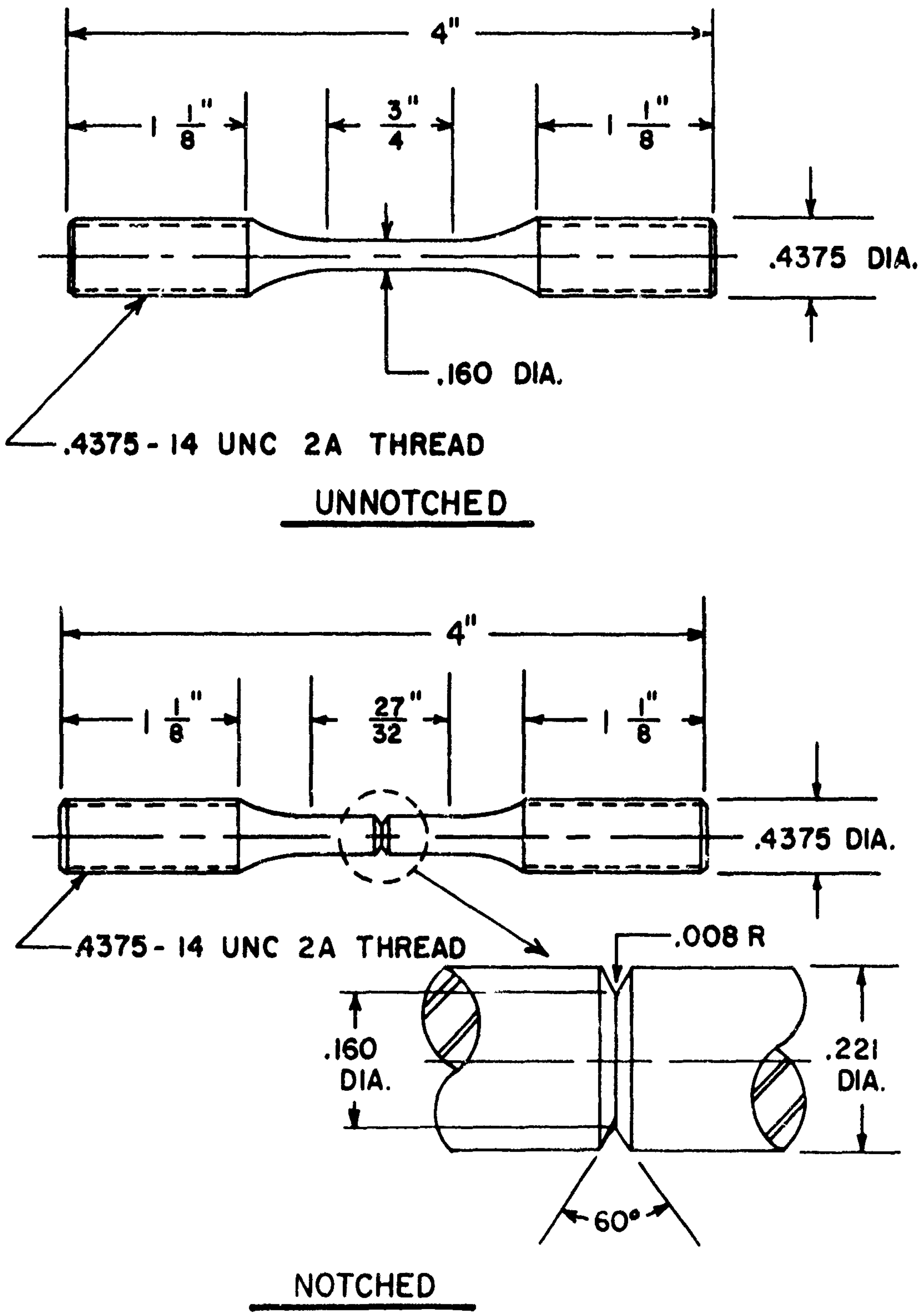

FIGURE 6 FATIGUE SPECIMENS

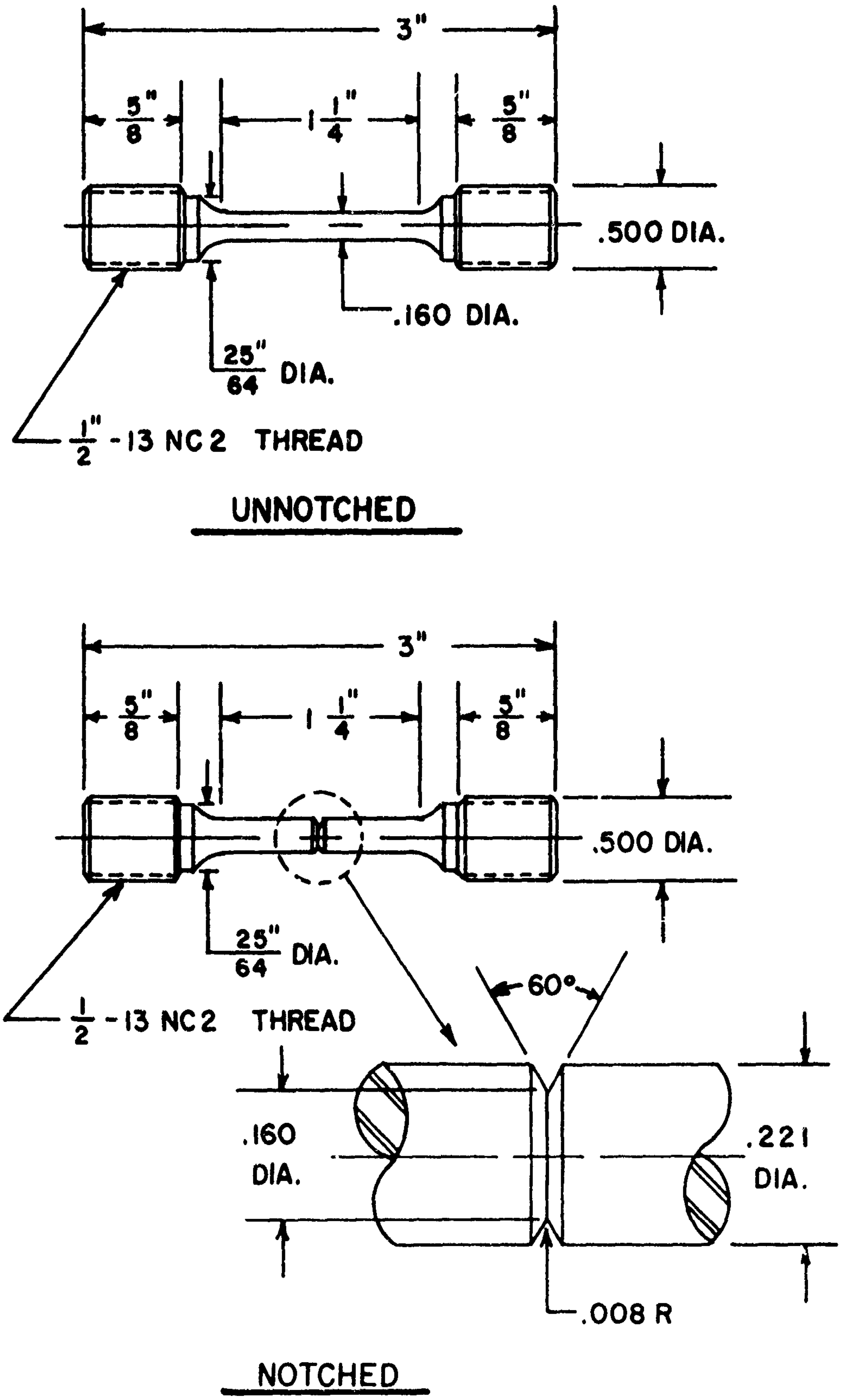

FIGURE 7 TENSILE & STRESS RUPTURE SPECIMENS

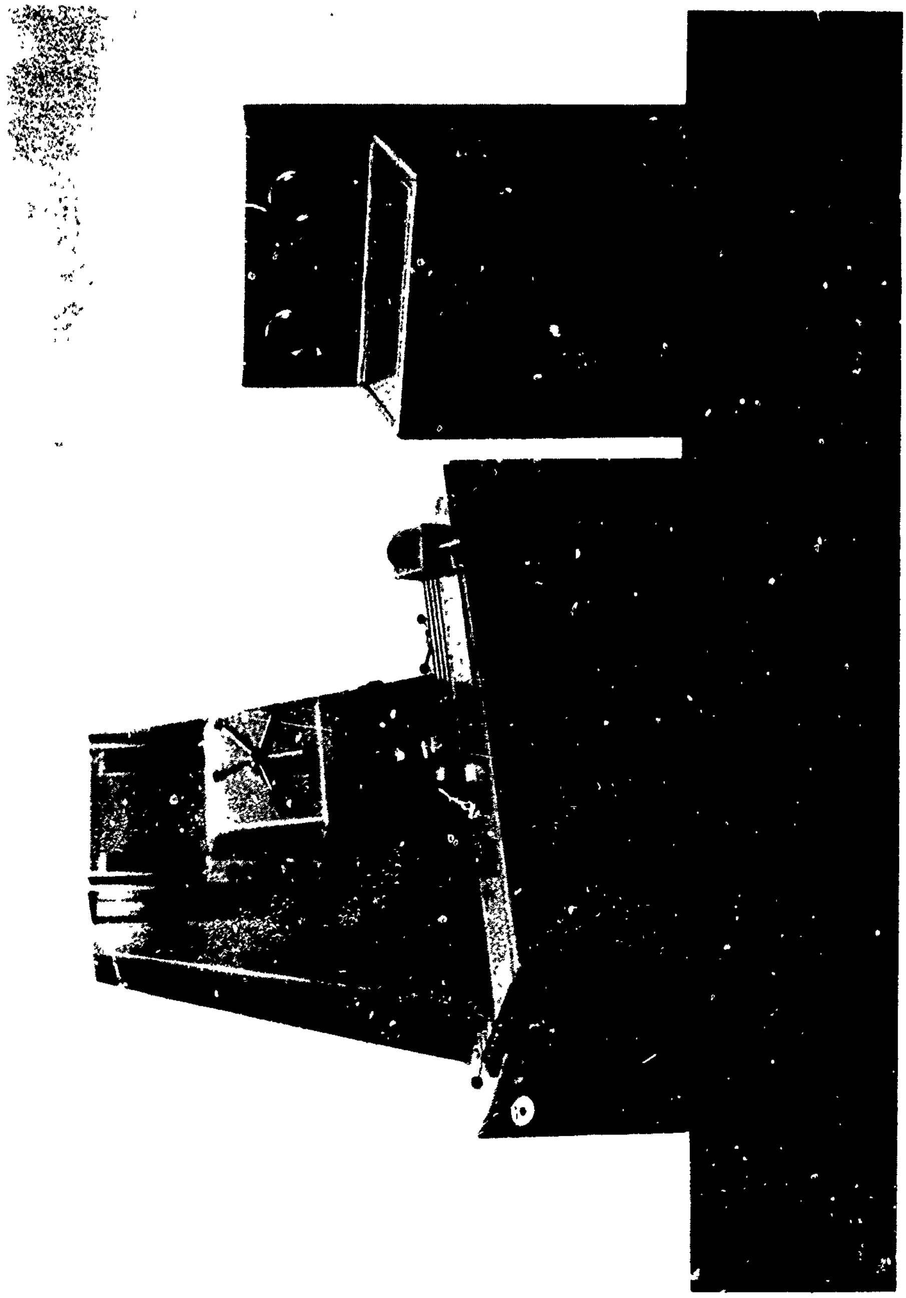

Figure 8. Schenck Fatigue Machine

this fatigue machine is such that both mean load and alternating load are automatically maintained constant during the life of the specimen. The machine operated at approximately 3100 cps during the test program, the exact speed being dependent upon the particular load being applied. A Siemens's three-zone furnace and controller were used in conjunction with the Schenck machine for the elevated temperature tests. The furnace and controller were calibrated using a hollow dummy specimen equipped with thermocouples. After initial proportioning of the three zones, longitudinal temperature distribution was held within $\pm 3^{o}$F. Average temperature was also held within $\pm 3^{o}$F.

The specimen grips and pull rod extensions are shown in Figure 9. The specimen is threaded into the pull rods and secured with lock nuts. The pull rods are attached to the load-carrying members of the machine by means of the usual pinned split-washer and lock nut arrangement, which permits torque-free specimen installation.

Figure 9 also shows the mechanism used for measurement of elongation during fatigue testing. This arrangement consists of a linear variable differential transformer activated by relative motion of the specimen grips. The output signal is amplified, rectified, and fed to a Rustrak recorder. Sensitivity was adjusted so that one centimeter on the recorder paper corresponded to .001 inch of elongation. The recorder paper was divided into divisions corresponding to .0002 inch, thus enabling a resolution of better than .0001 inch.

The Schenck machine normally utilizes the change in specimen stiffness, as a crack develops, to activate the shut-off mechanism. With the high-strength steel specimens, cracks developed so rapidly that the machine usually did not shut off for some period of time after the specimen had fractured, thus resulting in damage to the fracture surfaces. An accelerometer switch was attached to the lower grip and used to remove the driving power and to activate a braking system. This stopped the machine within a few seconds after specimen fracture.

The tensile and stress rupture tests were conducted by New England Materials Laboratory, Medford, Massachusetts. Tensile tests were conducted on a 60,000-pound Baldwin Universal testing machine equipped with an alundum-tube resistance furnace and Honeywell controller. Stress rupture tests were conducted on machines of New England Materials Laboratory design. These machines are also equipped with alundum tube resistance furnaces and Honeywell controllers in both machines. Temperatures were held to a maximum of $\pm 3^{o}$F. Although creep data were not a required aspect of the program, these data were taken on a number of specimens. The elongation during testing was measured by means of dial indicators activated by rods clamped to the specimen grips. Final elongation measurements were made on a predetermined gage length.

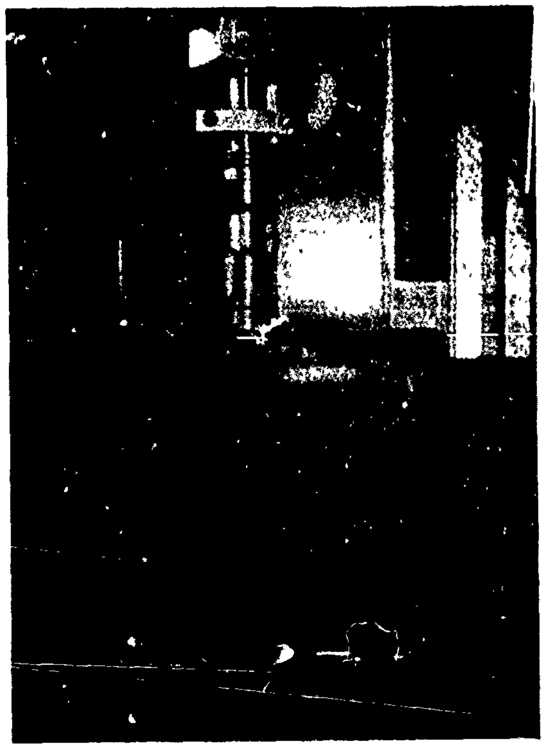

Figure 9. Mounting of Fatigue Specimen and Extensometer

IV. TEST SCHEDULE

An outline of the test program is given in Table 3. It will be noticed that tensile and fatigue tests were conducted at room temperature and at two elevated temperatures. Room-temperature stress-rupture tests, however, appeared impractical. Thus, these tests were conducted only at elevated temperatures. In the cases of the high-chromium die steels (Thermold J, Vascojet 1000, and Peerless 56) wherein usable strengths remain at 1000°F, tests were conducted at three elevated temperatures. Two elevated temperatures were selected for each of the other two materials.

As previously noted, specimen elongation was measured during the fatigue tests and a portion of the stress-rupture tests.

The stress-rupture loads were selected to allow interpolation to a rupture life of 55 hours. This time corresponds to that required for the accumulation of 10 million cycles by the Schenk fatigue machine. Thus, comparison of fatigue and creep stress levels and elongations can be made at corresponding lengths of life.

V. RESULTS

All detailed test data, except creep versus time data, are tabulated in the Appendix. The dynamic creep data were taken as continuous chart recordings and, hence, are not represented as discrete points. These data are, therefore, given as plots of elongation versus time. It will be noted that only a small number of fatigue specimens are represented on these plots. Most specimens did not show significant elongation and are thus considered as having exhibited no creep. This group consisted predominantly of specimens tested at room temperature, those tested under conditions of zero mean load and those which were notched. Static creep data are also presented as plots.

Modified Goodman Diagrams are presented in Figures 10 through 14. Fatigue data in these diagrams are taken as the values of stress at which a specimen would be expected to have a life of 10 million cycles. Under the test conditions, approximately 55 hours were required to accumulate this number of cycles. Thus, the rupture strengths at 55 hours were used for the corresponding points on the horizontal axes. These points were obtained by interpolation of the rupture diagrams, Figures 51 through 55.

TABLE 3

TEST CONDITIONS

Material	Notch	Stress Ratio (A)	Temperatures (°F)	Total Conditions	Specimens Per Condition
Tensile Tests					
D6AC	UN, N	0	75, 450, 550	6	3
LaBelle HT	UN, N	0	75, 450, 550	6	3
Thermold J	UN, N	0	75, 450, 1000	6	3
Vascojet 1000	UN, N	0	75, 800, 1000	6	3
Peerless 56	UN, N	0	75, 800, 1000	6	3
Fatigue Tests					
D6AC	UN, N	1, ∞	75, 450, 550	12	8
LaBelle HT	UN, N	1, ∞	75, 450, 550	12	8
Thermold J	UN, N	1, ∞	75, 450, 1000	12	8
Vascojet 1000	UN, N	1, ∞	75, 800, 1000	12	8
Peerless 56	UN, N	1, ∞	75, 800, 1000	12	8
Stress Rupture Tests					
D6AC	UN, N	0	450, 550	4	5
LaBelle HT	UN, N	0	450, 550	4	5
Thermold J	UN, N	0	450, 800, 1000	6	5
Vascojet 1000	UN, N	0	550, 800, 1000	6	5
Peerless 56	UN, N	0	550, 800, 1000	6	5

VI. DISCUSSION

A. Fatigue Characteristics

Examination of the modified Goodman Diagrams (Figures 10 through 14) shows that, for the most part, mean stress and temperature cause a decrease in the allowable alternating stress, as would be expected. Because of the limited number of stress ratios available, it is not possible to draw accurate curves of these effects. Thus, the test points are joined by straight lines.

The most notable unusual result is seen in the case of the Vascojet 1000 at room temperature. A marked drop in alternating stress to failure was observed at a stress ratio of 1.0 for the unnotched case. This point is, in fact, lower than the corresponding point for notched specimens. This can also be noted in the S-N Diagram, Figure 39, in the long-life region. A careful review of the test procedure was made on the suspicion of experimental error. No errors were found. Further, hardness checks and metallurgical examination indicate that the heat treatment was correct. There is a slight qualitative indication of hydrogen embrittlement. This is not apparent, however, in the tensile or stress-rupture data and, therefore, would have to be confined to the specimens used for the particular S-N Diagram. In any case, it is apparent that some unknown factor exists regarding this point on the Goodman Diagram and that the point should not be weighted heavily.

Figure 15 shows the appearance of the failed surfaces of this group of specimens. It can be seen that the failures started at or near the surface. This might suggest the possibility of bending loads in the machine. These particular tests were intermingled with others, however, which exhibited normal fatigue strengths. Figure 16 shows specimens from another test in which the failures were predominantly of subsurface origin, indicating good machine alignment.

Figure 17 is a plot of the fatigue limits as ratios of ultimate strengths for the parent materials at a stress ratio of infinity. The ratios hold reasonably constant with temperature and have values normally to be expected for very high strength steels.

Table 4 lists values of strength reduction factor, K_f, for the various materials. Values of notch sensitivity, q, are also tabulated. In this case "q" is based on a biaxial stress factor (K_T,) of 2.7, where the uniaxial factor (K_T) for the notches is 3.0. These values are determined from curves in Reference 1. Again, it can be seen that the Vascojet exhibited some rather unusual behavior.

TABLE 4

NOTCH SENSITIVITY

Stress Ratio A = ∞

$$q = \frac{K_f - 1}{K_{t'} - 1}$$

Material	Test Temperature (^oF)	K_f	q
D6AC	75	2.00	.59
	400	2.00	.59
	550	1.88	.52
LaBelle HT	75	1.8	.47
	400	1.75	.44
	550	1.75	.44
Thermold J	75	1.83	.49
	400	1.80	.47
	1000	1.56	.33
Vascojet 1000	75	1.80	.47
	800	2.29	.76
	1000	1.71	.42
Peerless 56	75	2.00	.59
	800	1.00	.29
	1000	1.55	.30

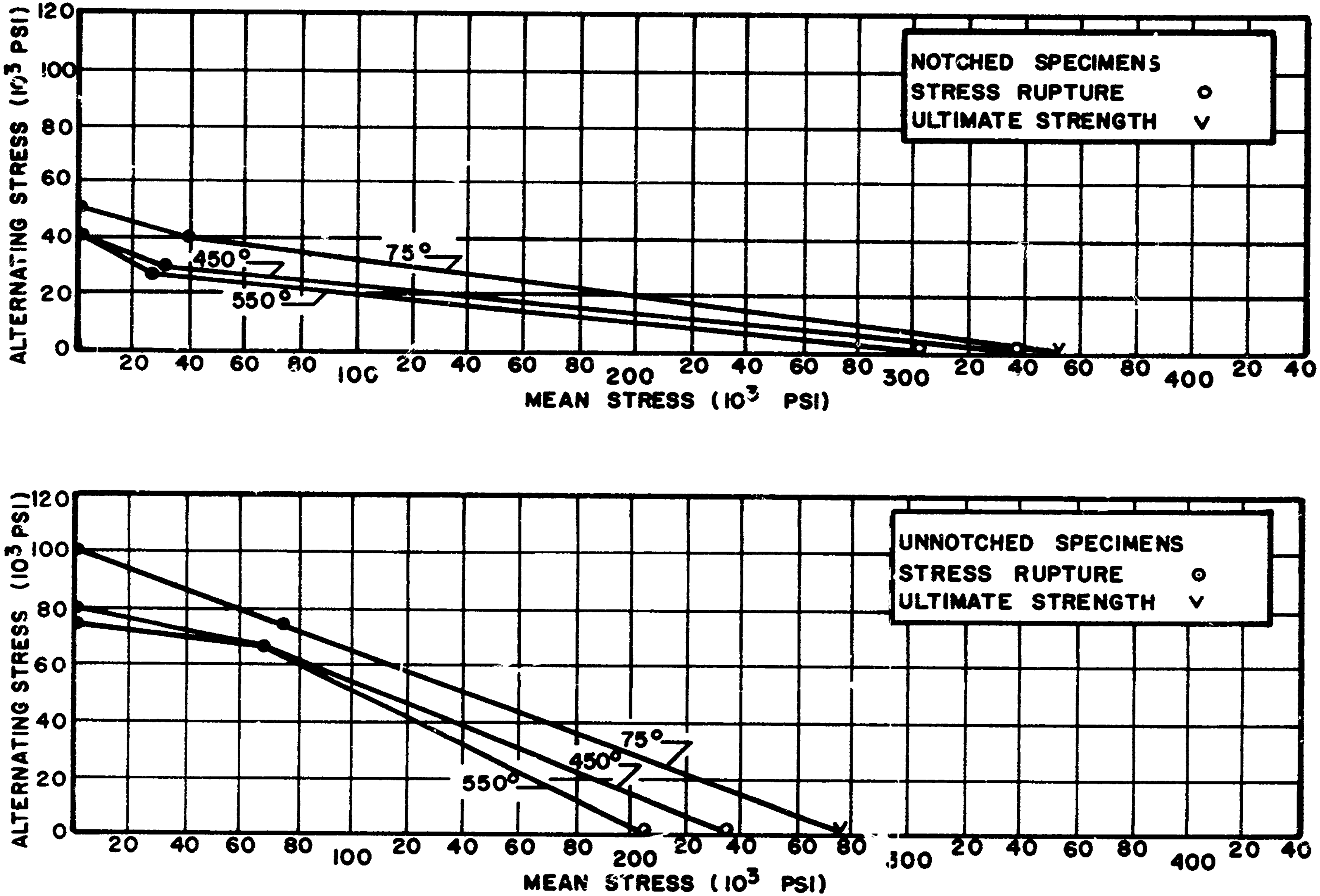

FIGURE 10 GOODMAN DIAGRAM: D6AC

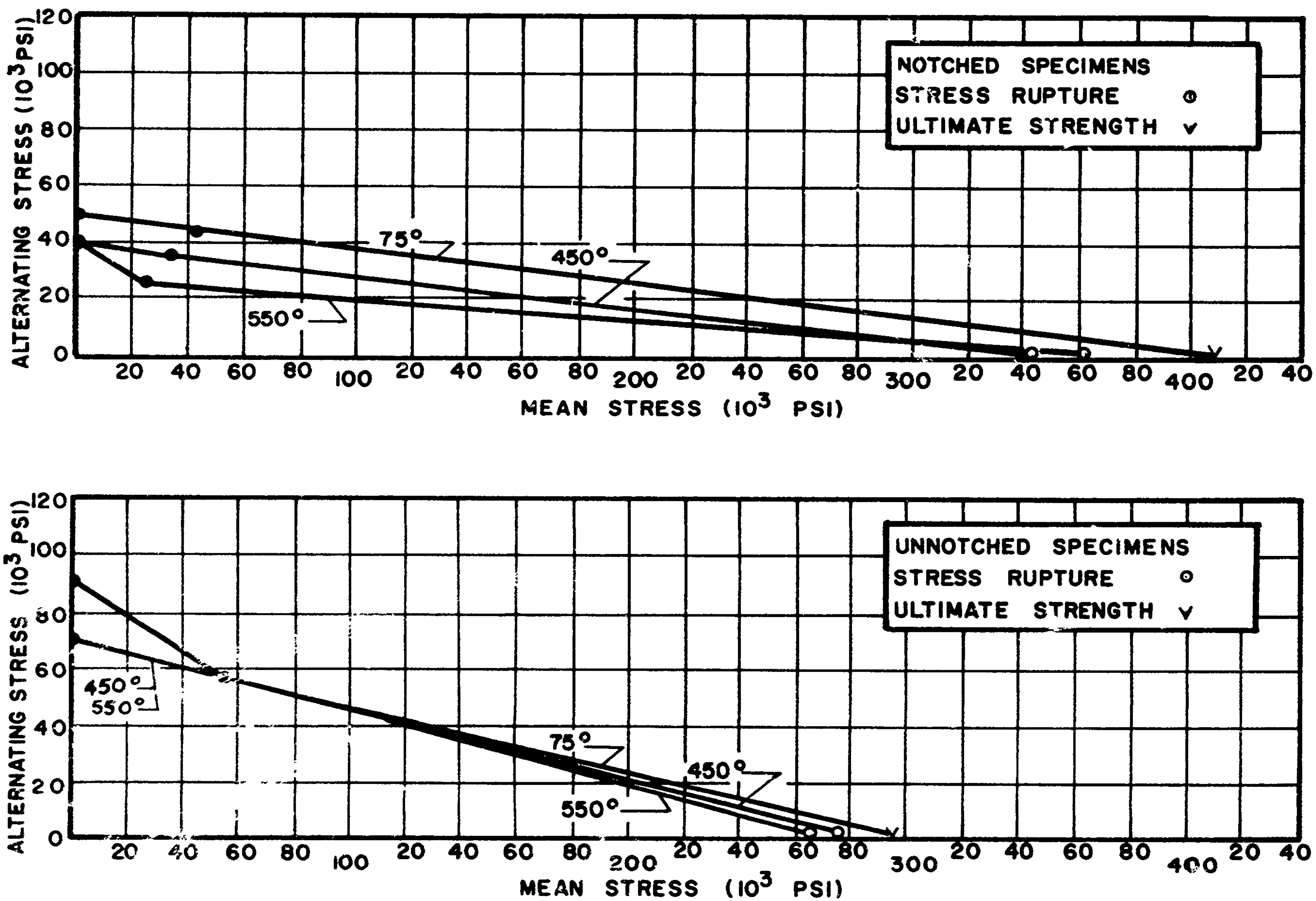

FIGURE II GOODMAN DIAGRAM: LABELLE HT

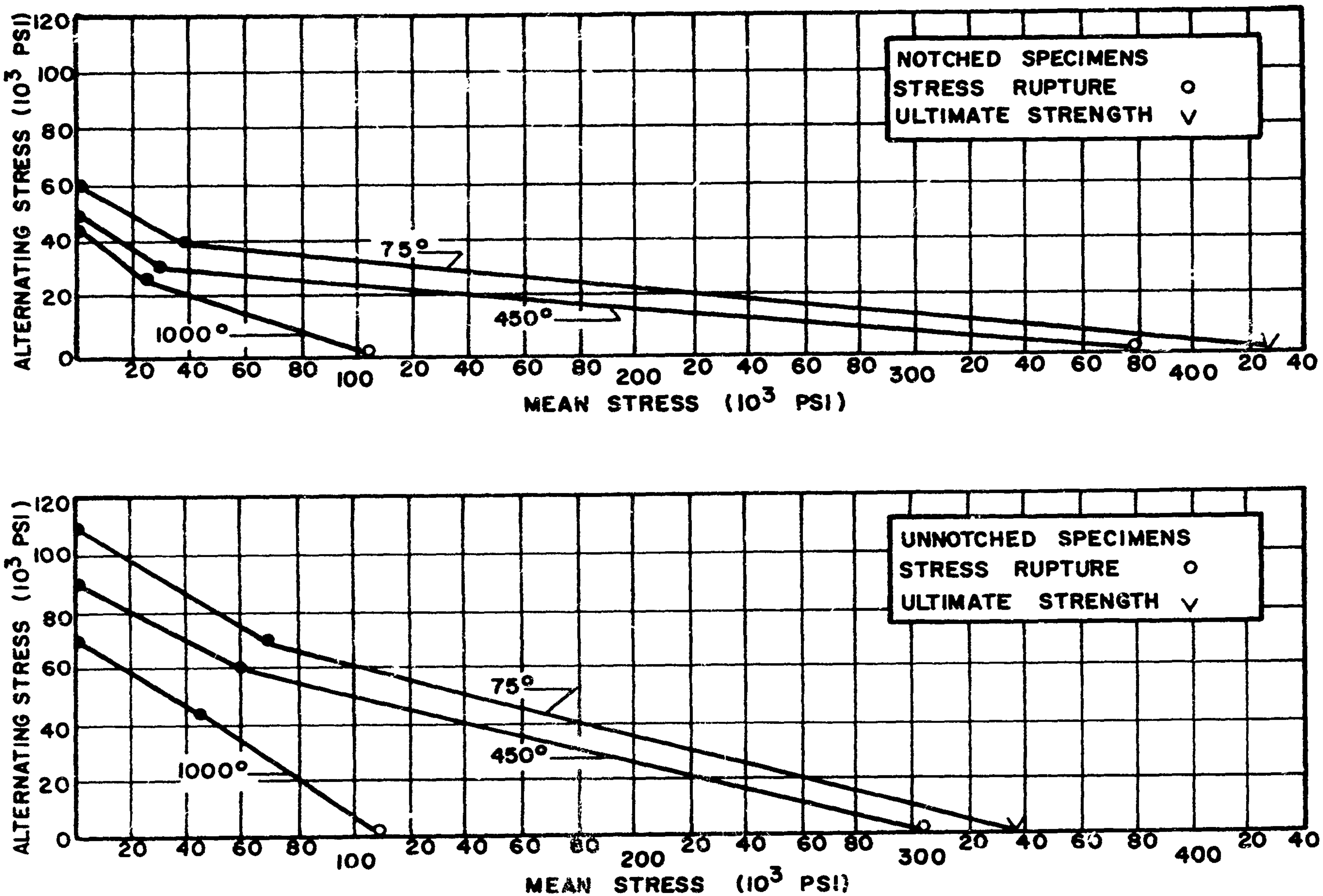

FIGURE 12 GOODMAN DIAGRAM: THERMOLD J

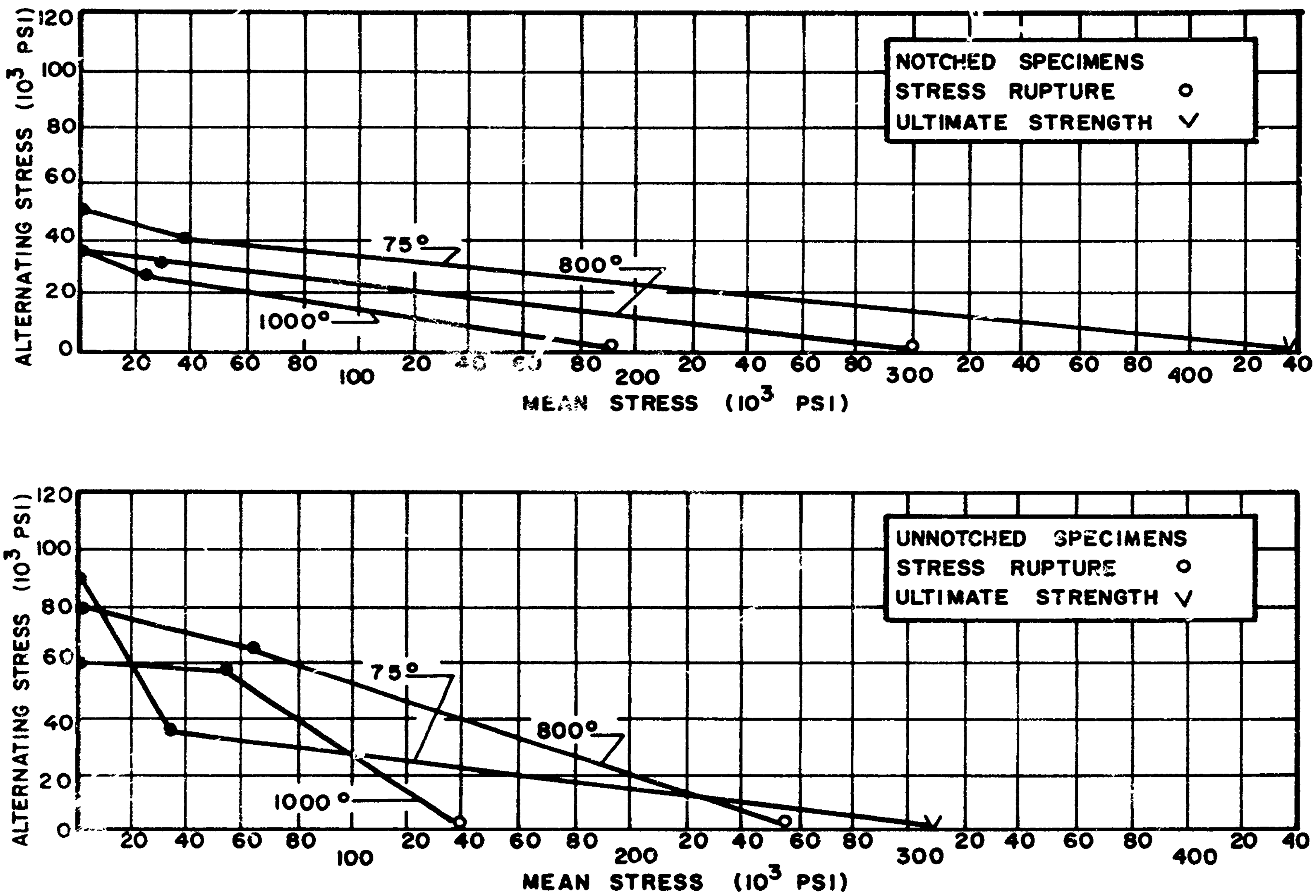

FIGURE 13 GOODMAN DIAGRAM: VASCOJET

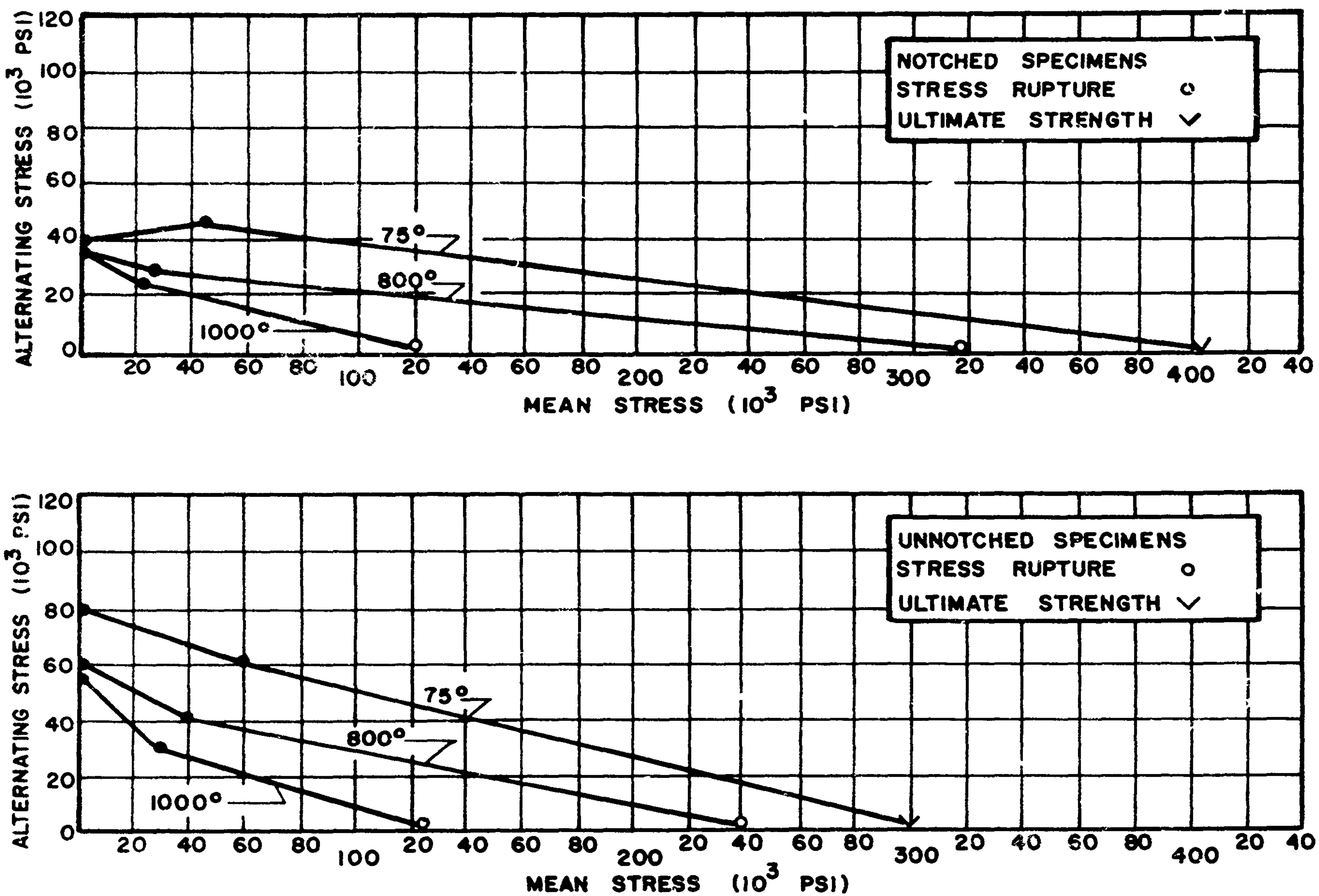

FIGURE 14 GOODMAN DIAGRAM: PEERLESS 56

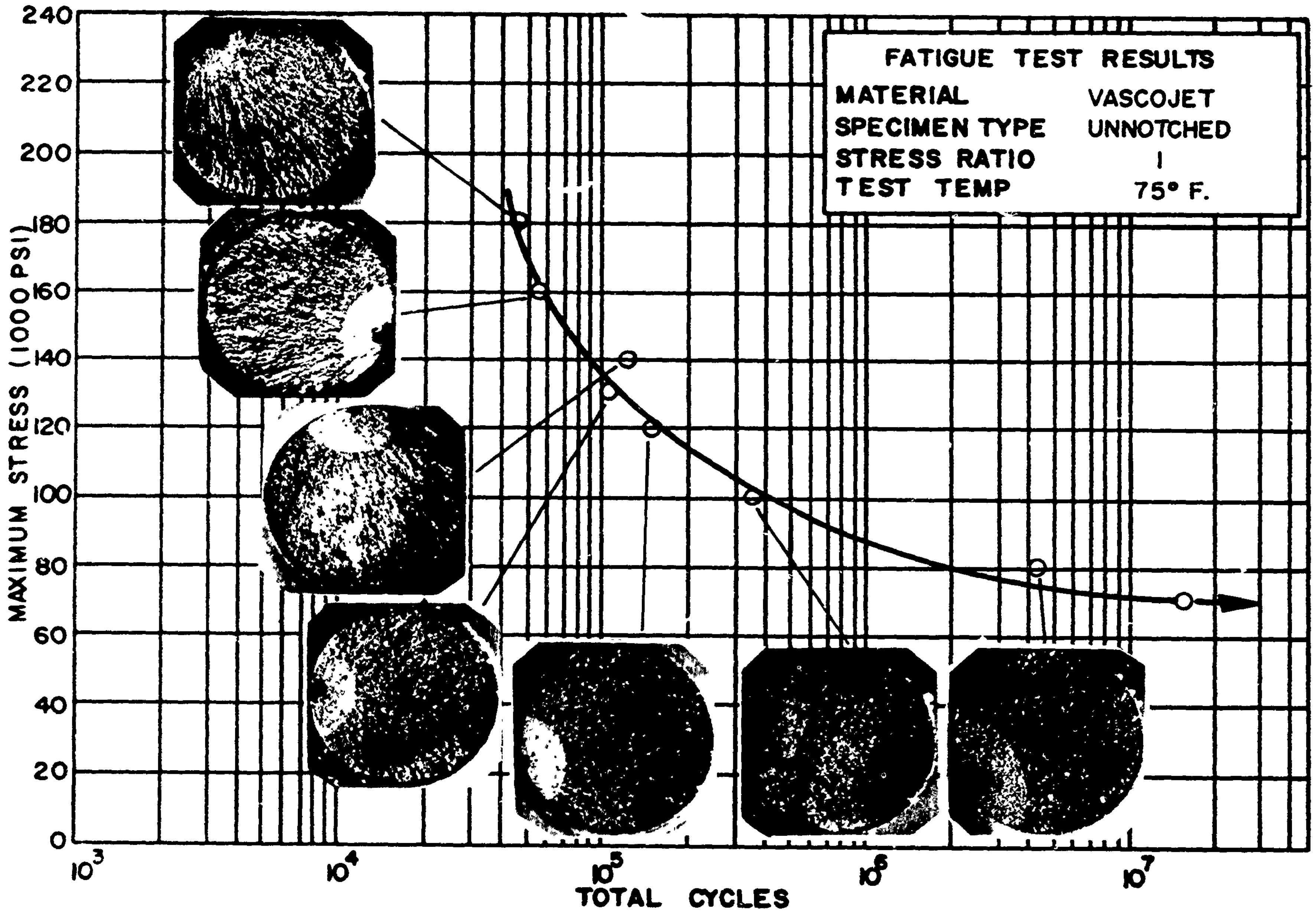

FIGURE 15 FAILURE SURFACES: VASCOJET 1000

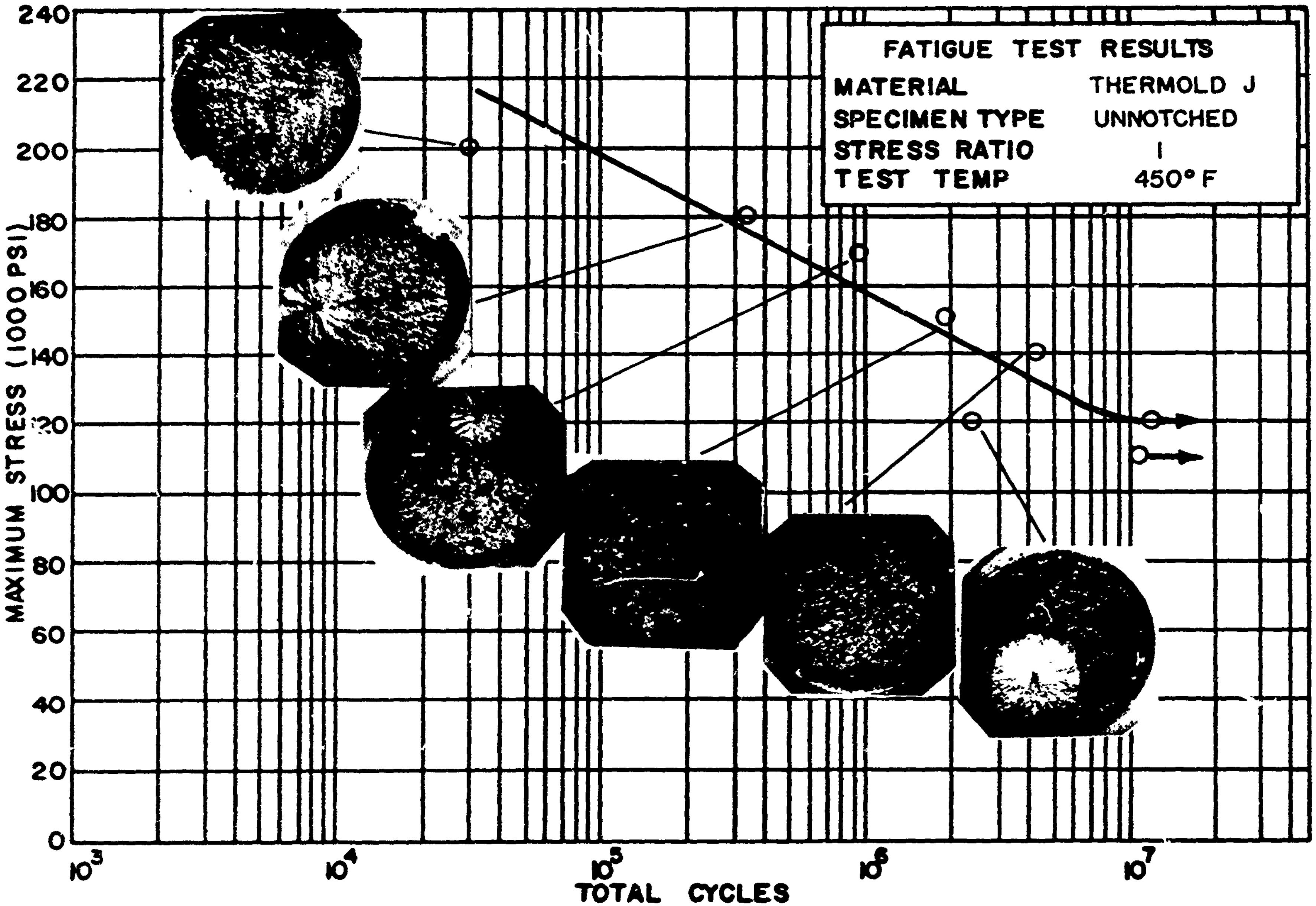

FIGURE 16 FAILURE SURFACES: THERMOLD J

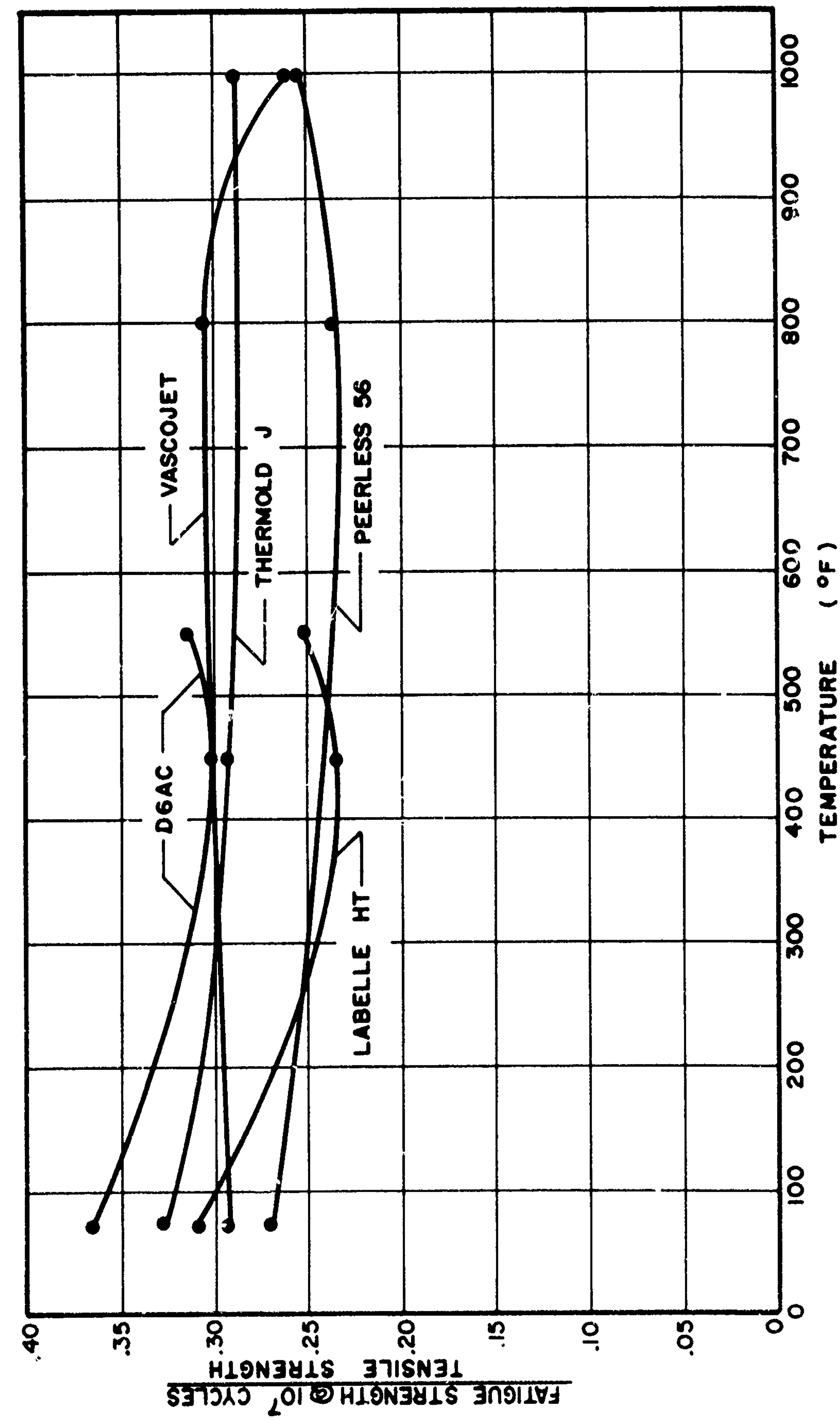

FIGURE 17 RATIO OF FATIGUE STRENGTH TO TENSILE STRENGTH: UNNOTCHED, A=∞

B. Stress Rupture Characteristics

Examination of the stress rupture plots, Figures 51 through 55, shows that the stress versus time function is very flat except for those tests conducted at 1000°F and the test of Peerless 56 at 800°F. As previously noted, the values for A = 0, as used in the Goodman Diagrams, were taken from these data, using a life of 55 hours. In cases wherein all data were at shorter times, the curves were extrapolated to 55 hours.

Examination of the failed surfaces of the stress rupture specimens revealed no consistent pattern. There was some tendency, at the higher temperatures, for the fractures to tend from transcrystalline to intercrystalline as the time to rupture increased.

Figures 18 and 19 show the elongation at fracture for failed specimens at the higher temperatures for each material. Although there is considerable variation in elongation at nearly constant stress, there is a definite trend, particularly at the highest temperatures, for final elongation to increase with stress level.

C. Creep

As previously mentioned, static creep versus time data were obtained on some of the stress rupture specimens and all of the fatigue specimens. The static data are given in Figures 56 through 67. The significant dynamic creep data are given in Figures 68 through 73. The difference in vertical scale between these two groups of figures should be noted. It can be seen that final elongation of the stress rupture specimens is about an order of magnitude greater than that of the fatigue specimens shown.

The static and dynamic creep data were examined rather thoroughly in an effort to arrive at a correlation with respect to the significant parameters, i.e. maximum stress, stress ratio, time and temperature. In particular, the data were examined to establish what effect, if any, the dynamic stress might have on creep behavior. Primarily because of the lack of experimental reference between the creep data and the fatigue data (i. e. the large difference in stress ratios or maximum stresses), correlation of the many factors is quite limited. It becomes apparent that, at the stress ratios involved, the predominant mode of failure in the dynamic tests was that of fatigue with very little elongation. The static tests were characterized generally by much greater elongations. There appears to be very little interaction between the two modes of failure under the conditions of test. Because of the nonlinear behavior of creep versus time in general, it is deemed hazardous to interpolate between the two extremes of fatigue and stress rupture loading condition. This is further pointed out by Lazan (Ref. 2, 3) who notes that theoretical expressions are available but that, because of the associated assumptions, they must be used with extreme caution if serious errors are to be avoided.

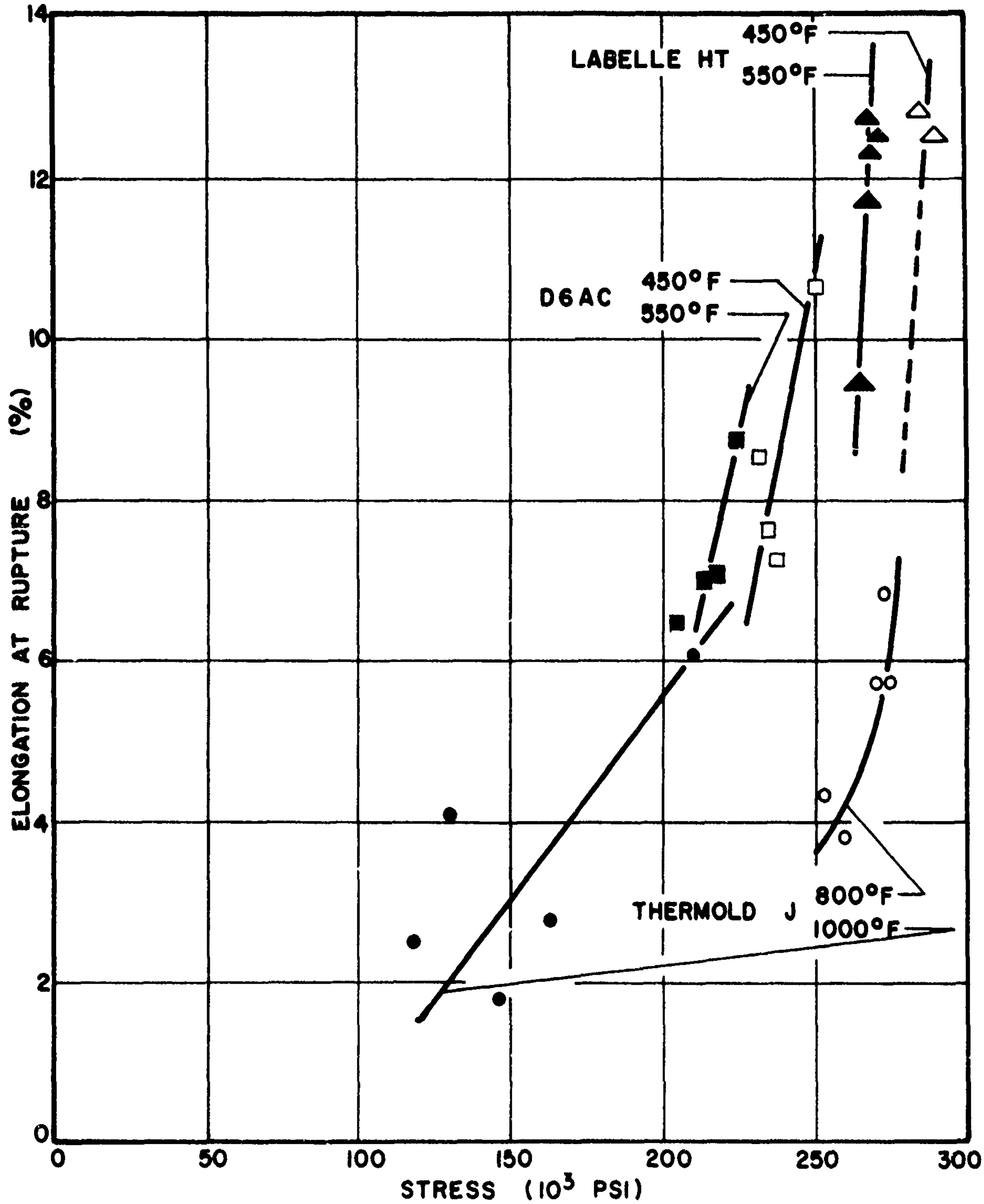

FIGURE 18 FINAL ELONGATION OF STRESS RUPTURE SPECIMENS

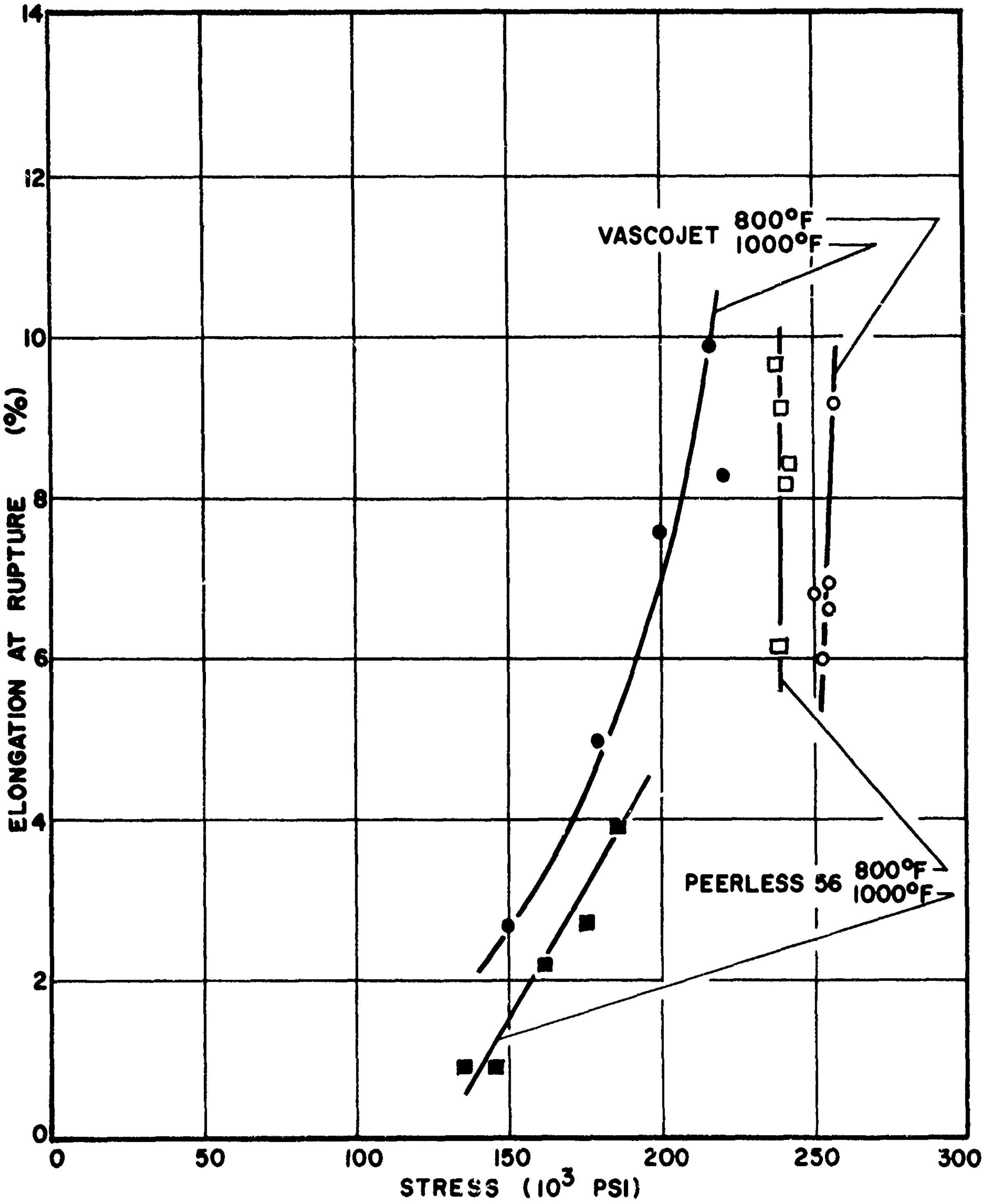

FIGURE 19 FINAL ELONGATION OF STRESS RUPTURE SPECIMENS (CONTINUED)

Theory and experiment do not compare well. It thus remains necessary to resort to experiment if knowledge of the interaction of static and dynamic loads on creep behavior of specific materials is to be obtained. This is particularly true in the area where interaction is greatest; at stress ratios (A) between zero and one.

Examination of the dynamic creep data indicates that significant creep occurred only under the combination of elevated temperature and pressure of mean stress (A = 1) in the unnotched specimens. Several parameters were plotted in an effort to depict this effect. The only one which resulted in a reasonable plot without excessive scatter was that of the product of stress and time. It is realized, of course, that under the conditions of test,these variables are not completely independent. Figure 20 gives the result of the use of the stress-time parameter and shows the effect of mean stress on total dynamic creep at fracture for unnotched specimens. Only tests of unnotched specimens at 1000°F are shown and only those specimens which showed creep other than zero are plotted.

It is not possible to conclude from the data in Figure 20 that the dynamic stress has an effect on creep. Static data plotted in this same manner would yield very much higher values of elongation for the same value of the stress-time parameter. This might be expected as a result of the greatly different stress levels between the two types of test. Thus, the only positive conclusion can be that the mean stress in the fatigue tests at high temperature and a stress ratio of 1.0 is sufficient to cause a small amount of creep. No conclusions regarding the effect of the dynamic load can be drawn. In other words, no data on static creep at stress levels corresponding to those in the dynamic tests are available for comparison.

D. General Comments

The following additional general observations were made, particularly with regard to the appearance of the fatigue fractures:

1. Microscopic examination of the failed surfaces of the groups of specimens which exhibited unusual fatigue behavior did not reveal any apparent differences in mode of fracture as compared to those displaying normal behavior. This comment applies particularly to the LaBelle HT at 450°F and the Vascojet at 75°F and 800°F.

2. Fatigue curves were examined with respect to the presence of inclusions and the size of inclusions at which fatigue failure nucleated. Although a number of spherical inclusions as large as 0.003-0.004 inch diameter were observed, their presence and size did not correlate with fatigue strengths of the individual specimens.

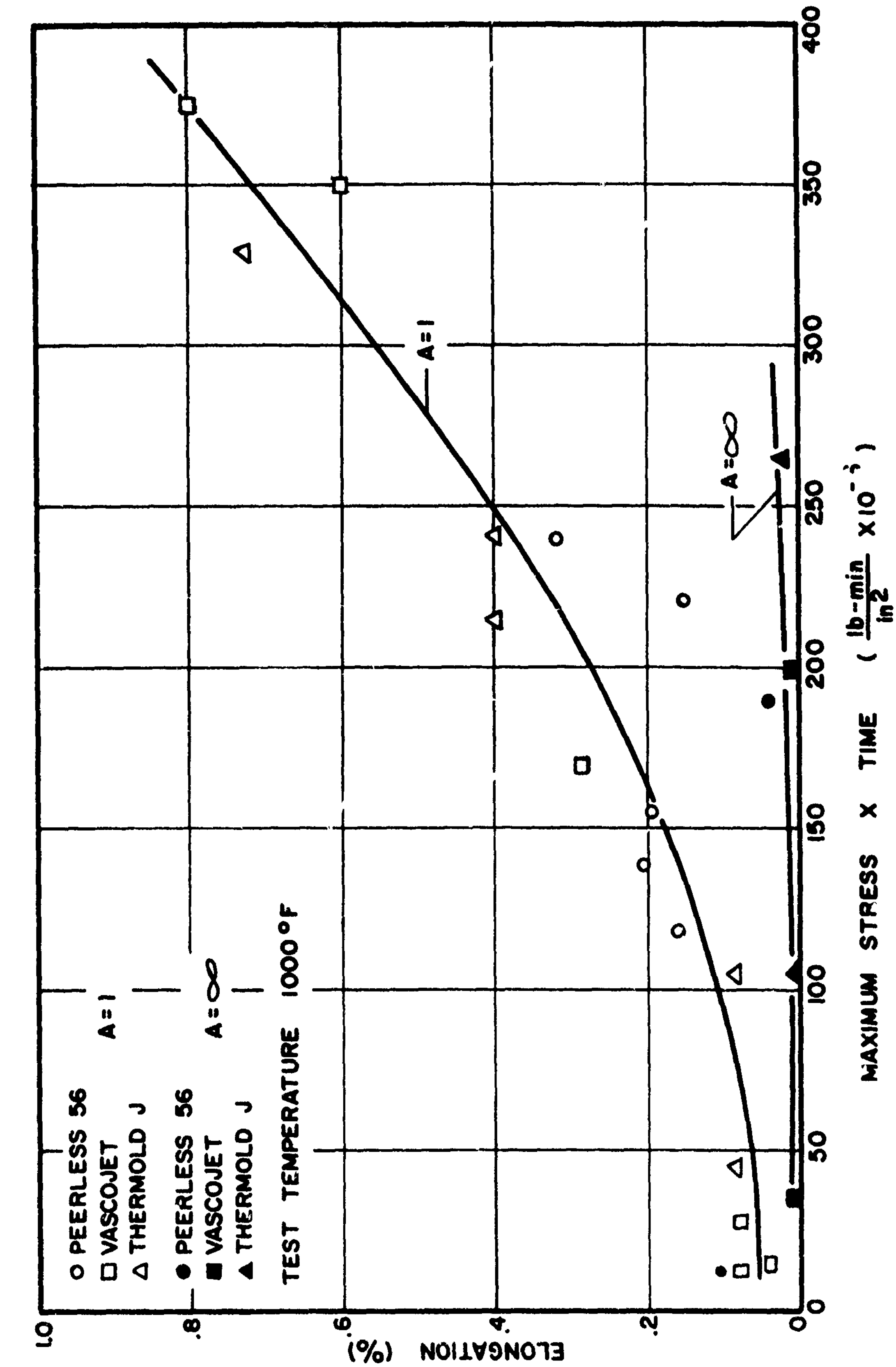

FIGURE 20 EFFECT OF MEAN STRESS ON CREEP UNDER FATIGUE LOADING

3. The fractured surfaces of the high-temperature fatigue specimens exhibited a greater degree of shear failure than did those at the lower temperatures. As a result, the high-temperature failures are quite jagged in appearance. The low-temperature specimens all exhibited some degree of shear failure. This is fairly constant in degree at all stress levels and tends to be uniformly distributed around the circumference.

4. At the higher temperatures a number of specimens exhibited a fluted formation in the fatigue area. At lower temperatures there is a suggestion of the same mechanism, but it never becomes fully developed.

VII. CONCLUSIONS

1. Extensive data were obtained on the tensile, stress rupture and fatigue properties of five high-strength steels at room and elevated temperatures in both the unnotched and the notched conditions. Dynamic creep data were obtained in connection with the fatigue tests.

2. Dynamic creep was shown to be very small under most conditions of test. Creep of significant degree occurred only under conditions of maximum test temperature and maximum mean load ($A = 1$) for the unnotched specimens. All other fatigue tests resulted in very small creep, generally within the limits of resolution of the extensometer. The maximum dynamic creep observed was 0.8%, this being confined to a single specimen.

3. Inasmuch as static creep data were not available at stress levels corresponding to those used in the fatigue tests, no conclusions can be reached regarding the influence of dynamic stress on creep.

4. The ratio of fatigue strength (at 10 million cycles) to ultimate tensile strength ranged from 0.23 to 0.37 for the unnotched materials at a stress ratio of $A = \infty$.

VIII. LIST OF REFERENCES

1. Peterson, R. E. Stress Concentration Factors in Design. John Wiley & Sons, New York, 1953.

2. Lazan, B. J. Fatigue of Structural Materials at High Temperatures. NATO Report No. 156, November 1957.

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APPENDIX

The following Appendix contains the detailed test data in the forms of tables and curves. Please refer to the Table of Contents for an index to this information.

TABLE 5

FATIGUE TEST DATA - D6AC

Heat Number: S9706

Heat Treatment: Heat to 1500°F in slightly oxidizing atmosphere. Hold 15 minutes. Oil quench. Temper 500°F, 2 hours.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
D1	UN	75	1	160,000	183,100	.0000
D2	UN	75	1	140,000	13,001,300*	.0000
D3	UN	75	1	180,000	78,200	.0000
D4	UN	75	1	200,000	39,000	.0000
D5	UN	75	1	220,000	26,300	.0000
D6	UN	75	1	170,000	437,900	.0000
D7	UN	75	1	150,000	14,173,100*	.0000
D8	UN	75	1	170,000	122,300	.0000
D9	UN	75	∞	160,000	20,000	.0000
D10	UN	75	∞	140,000	38,500	.0000
D11	UN	75	∞	120,000	71,700	.0000
D12	UN	75	∞	100,000	90,400	.0000
D13	UN	75	∞	80,000	13,294,800*	.0000
D14	UN	75	∞	100,000	19,538,000*	.0000
D15	UN	75	∞	110,000	93,500	.0000
D16	UN	75	∞	100,000	11,106,800*	.0000
D49	N	75	1	140,000	7,100	.0000
D50	N	75	1	120,000	12,600	.0000
D51	N	75	1	80,000	229,000	.0000
D52	N	75	1	100,000	54,300	.0000
D53	N	75	1	60,000	13,639,400*	.0000
D54	N	75	1	80,000	10,592,400*	.0000
D55	N	75	1	90,000	61,600	.0000
D56	N	75	1	110,000	33,200	.0000
D57	N	75	∞	100,000	7,900	.0000
D58	N	75	∞	80,000	13,000	.0000
D59	N	75	∞	60,000	72,100	.0000
D60	N	75	∞	40,000	15,699,200*	.0000
D61	N	75	∞	70,000	25,300	.0000
D62	N	75	∞	50,000	1,438,000	.0000
D63	N	75	∞	50,000	17,021,100*	.0000
D64	N	75	∞	65,000	33,000	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 5 (CONTINUED)

FATIGUE TEST DATA - D6AC

Heat Number: S9706

Heat Treatment: Heat to 1500°F in slightly oxidizing atmosphere. Hold 15 minutes. Oil quench. Temper 500°F, 2 hours.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
D17	UN	450	1	140,000	6,601,900	.0008
D18	UN	450	1	180,000	22,700	.0000
D19	UN	450	1	160,000	1,322,700	.0000
D20	UN	450	1	150,000	3,163,400	.0003
D21	UN	450	1	170,000	369,300	.0000
D22	UN	450	1	200,000	41,400	.0000
D23	UN	450	1	135,000	9,114,600	.0004
D24	UN	450	1	135,000	6,541,700	.0001
D25	UN	450	∞	100,000	1,428,800	.0000
D26	UN	450	∞	110,000	451,900	.0000
D27	UN	450	∞	130,000	46,500	.0000
D28	UN	450	∞	90,000	3,719,900	.0003
D29	UN	450	∞	80,000	13,107,300*	.0002
D30	UN	450	∞	120,000	160,100	.0000
D31	UN	450	∞	110,000	517,300	.0004
D32	UN	450	∞	95,000	1,555,400	.0000
D Spare	UN	450	1	135,000	13,050,000*	.0003
D65	N	450	1	100,000	13,700	.0000
D66	N	450	1	60,000	10,555,800*	.0002
D67	N	450	1	100,000	23,400	.0000
D68	N	450	1	90,000	32,700	.0000
D69	N	450	1	80,000	551,300	.0000
D70	N	450	1	70,000	1,014,700	.0000
D71	N	450	1	75,000	902,200	.0000
D72	N	450	1	85,000	42,300	.0000
D73	N	450	∞	45,000	143,700	.0000
D74	N	450	∞	40,000	7,615,600	.0002
D75	N	450	∞	40,000	12,075,000*	.0004
D76	N	450	∞	50,000	55,000	.0000
D77	N	450	∞	55,000	41,500	.0000
D78	N	450	∞	60,000	42,100	.0000
D79	N	450	∞	65,000	23,100	.0000
D80	N	450	∞	70,000	19,600	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 5 (CONTINUED)

FATIGUE TEST DATA - D6AC

Heat Number: S9706

Heat Treatment: Heat to 1500°F in slightly oxidizing atmosphere. Hold 15 minutes. Oil quench. Temper 500°F, 2 hours.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure*	Dynamic Creep**
D33	UN	550	1	180,000	48,300	.0000
D34	UN	550	1	160,000	618,100	.0000
D35	UN	550	1	150,000	724,700	.0000
D36	UN	550	1	200,000	13,100	.0000
D37	UN	550	1	150,000	1,599,500	.0002
D38	UN	550	1	140,000	5,893,800	.0005
D39	UN	550	1	130,000	10,125,000*	.0004
D40	UN	550	1	135,000	13,450,000*	.0006
D41	UN	550	∞	140,000	19,800	.0000
D42	UN	550	∞	120,000	199,800	.0000
D43	UN	550	∞	100,000	1,217,300	.0000
D44	UN	550	∞	90,000	2,992,300	.0005
D45	UN	550	∞	110,000	162,900	.0000
D46	UN	550	∞	80,000	2,672,600	.0000
D47	UN	550	∞	80,000	7,423,800	.0000
D48	UN	550	∞	75,000	12,462,000*	.0002
D81	N	550	1	100,000	20,000	.0000
D82	N	550	1	90,000	23,300	.0000
D83	N	550	1	80,000	163,000	.0000
D84	N	550	1	70,000	642,900	.0000
D85	N	550	1	60,000	4,854,100	.0000
D86	N	550	1	55,000	10,100,000*	.0000
D87	N	550	1	90,000	39,500	.0000
D88	N	550	1	80,000	79,900	.0000
D89	N	550	∞	60,000	34,800	.0000
D90	N	550	∞	50,000	82,700	.0000
D91	N	550	∞	40,000	15,550,000*	.0000
D92	N	550	∞	70,000	13,900	.0000
D93	N	550	∞	65,000	17,400	.0000
D94	N	550	∞	55,000	37,000	.0000
D95	N	550	∞	45,000	248,800	.0000
D96	N	550	∞	55,000	59,400	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 6

FATIGUE TEST DATA - LABELLE HT

Heat No.: 53428

Heat Treatment: Heat to 1700°F in slightly reducing atmosphere. Hold 10 minutes. Oil quench. Temper immediately 2 hours, 550°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
H2	UN	75	1	130,000	5,076,000	.0000
H3	UN	75	1	150,000	606,600	.0000
H4	UN	75	1	120,000	499,300	.0000
H5	UN	75	1	120,000	8,070,400	.0000
H6	UN	75	1	110,000	12,581,000*	.0000
H7	UN	75	1	170,000	90,400	.0000
H8	UN	75	1	180,000	50,300	.0000
H9	UN	75	1	230,000	16,900	.0000
H10	UN	75	∞	100,000	4,975,500	.0000
H11	UN	75	∞	110,000	996,000	.0000
H12	UN	75	∞	120,000	177,800	.0000
H13	UN	75	∞	100,000	7,074,800	.0000
H14	UN	75	∞	130,000	43,300	.0000
H15	UN	75	∞	90,000	2,775,500	.0000
H16	UN	75	∞	80,000	10,138,000*	.0000
H17	UN	75	∞	150,000	17,500	.0000
H18	UN	75	∞	90,000	10,140,000*	.0000
H49	N	75	1	150,000	13,400	.0000
H51	N	75	1	75,000	10,110,000*	.0000
H52	N	75	1	85,000	16,891,200*	.0000
H57	N	75	1	90,000	55,100	.0000
H62	N	75	1	90,000	1,237,800	.0000
H64	N	75	1	100,000	95,400	.0000
H70	N	75	1	120,000	14,900	.0000
H83	N	75	1	85,000	10,433,100	.0000
H65	N	75	∞	60,000	2,302,100	.0000
H66	N	75	∞	90,000	6,800	.0000
H67	N	75	∞	40,000	10,862,700*	.0000
H68	N	75	∞	80,000	14,400	.0000
H72	N	75	∞	70,000	40,300	.0000
H73	N	75	∞	65,000	65,600	.0000
H76	N	75	∞	60,000	144,700	.0000
H77	N	75	∞	50,000	10,173,100*	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 6 (CONTINUED)

FATIGUE TEST DATA - LABELLE HT

Heat No.: 53428

Heat Treatment: Heat to 1700°F in slightly reducing atmosphere. Hold 10 minutes. Oil quench. Temper immediately 2 hours, 550°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
H23	UN	450	1	100,000	10,600,000*	.0002
H24	UN	450	1	140,000	183,000	.0000
H25	UN	450	1	120,000	2,300,000	.0000
H27	UN	450	1	120,000	8,004,200	.0002
H31	UN	450	1	180,000	21,400	.0000
H32	UN	450	1	160,000	115,400	.0000
H33	UN	450	1	110,000	10,650,000*	.0002
H47	UN	450	1	130,000	325,000	.0000
H1	UN	450	∞	80,000	1,367,100	.0002
H19	UN	450	∞	100,000	2,118,100	.0002
H20	UN	450	∞	140,000	29,900	.0000
H21	UN	450	∞	120,000	41,000	.0000
H22	UN	450	∞	90,000	2,387,300	.0000
H26	UN	450	∞	70,000	10,036,600*	.0002
H28	UN	450	∞	110,000	157,200	.0000
H29	UN	450	∞	80,000	2,291,700	.0000
H53	N	450	1	120,000	7,900	.0000
H54	N	450	1	100,000	10,500	.0000
H55	N	450	1	80,000	1,896,200	.0004
H56	N	450	1	90,000	24,700	.0000
H58	N	450	1	75,000	6,938,500	.0002
H59	N	450	1	70,000	11,241,400*	.0000
H60	N	450	1	110,000	16,600	.0000
H61	N	450	1	90,000	27,900	.0000
H63	N	450	∞	40,000	10,033,800*	.0000
H71	N	450	∞	50,000	527,300	.0000
H74	N	450	∞	60,000	45,100	.0000
H75	N	450	∞	70,000	21,300	.0000
H78	N	450	∞	80,000	10,000	.0000
H79	N	450	∞	65,000	21,700	.0000
H80	N	450	∞	45,000	7,914,000	.0002
H81	N	450	∞	45,000	2,431,500	.0002

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 6 (CONTINUED)

FATIGUE TEST DATA - LABELLE HT

Heat No.: 53428

Heat Treatment: Heat to 1700°F in slightly reducing atmosphere. Hold 10 minutes. Oil quench. Temper immediately 2 hours, 550°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
H30	UN	550	1	160,000	16,600	.0000
H34	UN	550	1	140,000	142,200	.0000
H35	UN	550	1	110,000	11,942,700*	.0004
H36	UN	550	1	150,000	40,800	.0000
H37	UN	550	1	130,000	151,200	.0000
H38	UN	550	1	130,000	150,300	.0000
H39	UN	550	1	120,000	211,700	.0000
H40	UN	550	1	115,000	3,830,200	.0002
H41	UN	550	∞	120,000	13,700	.0000
H42	UN	550	∞	70,000	11,591,000*	.0005
H43	UN	550	∞	110,000	35,200	.0000
H44	UN	550	∞	100,000	129,300	.0000
H45	UN	550	∞	80,000	945,000	.0000
H46	UN	550	∞	90,000	337,800	.0000
H47A	UN	550	∞	100,000	115,200	.0000
H48	UN	550	∞	75,000	3,067,100	.0000
H82	N	550	1	100,000	8,800	.0000
H84	N	550	1	90,000	20,100	.0000
H85	N	550	1	80,000	1,243,300	.0000
H86	N	550	1	85,000	110,300	.0000
H87	N	550	1	85,000	126,900	.0000
H88	N	550	1	70,000	10,486,800*	.0000
H89	N	550	1	75,000	No Data-Loose Locknut	
H90	N	550	1	75,000	3,620,300	.0000
H91	N	550	∞	50,000	1,665,000	.0000
H92	N	550	∞	80,000	7,800	.0000
H93	N	550	∞	70,000	15,500	.0000
H94	N	550	∞	60,000	48,900	.0000
H95	N	550	∞	40,000	11,700,000*	.0000
H96	N	550	∞	45,000	1,013,000	.0000
H73	N	550	∞	55,000	31,400	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 7

FATIGUE TEST DATA - THERMOLD J

Heat No.: D21144

Heat Treatment: Heat to 1850°F and hold 15 minutes. Air cool. Double temper 2 hours, plus 2 hours at 1000°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep **
J1	UN	75	1	110,000	11,236,300	.0000
J2	UN	75	1	130,000	15,010,100*	.0000
J3	UN	75	1	160,000	3,025,400	.0000
J4	UN	75	1	180,000	103,500	.0000
J5	UN	75	1	170,000	2,750,500	.0000
J6	UN	75	1	200,000	56,600	.0000
J7	UN	75	1	230,000	11,700	.0000
J8	UN	75	1	150,000	5,913,500	.0000
J9	UN	75	∞	100,000	15,378,900*	.0000
J10	UN	75	∞	140,000	2,369,700	.0000
J11	UN	75	∞	160,000	418,200	.0000
J12	UN	75	∞	180,000	16,300	.0000
J13	UN	75	∞	150,000	560,300	.0000
J14	UN	75	∞	120,000	4,651,900	.0000
J15	UN	75	∞	170,000	60,500	.0000
J49	N	75	1	120,000	20,600	.0000
J50	N	75	1	100,000	136,200	.0000
J51	N	75	1	80,000	11,001,000	.0000
J52	N	75	1	110,000	36,300	.0000
J53	N	75	1	140,000	140,000	.0000
J54	N	75	1	90,000	232,900	.0000
J55	N	75	1	80,000	23,068,100*	.0000
J56	N	75	1	100,000	101,706	.0000
J57	N	75	∞	80,000	159,700	.0000
J58	N	75	∞	100,000	8,700	.0000
J59	N	75	∞	60,000	14,382,000*	.0000
J60	N	75	∞	70,000	341,900	.0000
J61	N	75	∞	70,000	100,200	.0000
J62	N	75	∞	70,000	598,100	.0000
J63	N	75	∞	No Data-Loose Locknut		
J64	N	75	∞	90,000	101,800	.0000
J65	N	75	∞	80,000	30,800	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 7 (CONTINUED)

FATIGUE TEST DATA - THERMOLD J

Heat No.: D21144

Heat Treatment: Heat to 1850°F and hold 15 minutes. Air cool. Double temper 2 hours, plus 2 hours at 1000°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep **
J16	UN	450	1	120,000	2,563,400	.0000
J17	UN	450	1	110,000	10,165,600*	.0000
J18	UN	450	1	140,000	4,231,900	.0000
J19	UN	450	1	180,000	352,000	.0000
J20	UN	450	1	200,000	30,000	.0000
J21	UN	450	1	150,000	1,898,000	.0000
J22	UN	450	1	170,000	989,800	.0000
J23	UN	450	1	120,000	12,474,700*	.0000
J24	UN	450	∞	160,000	143,500	.0000
J25	UN	450	∞	140,000	848,700	.0000
J26	UN	450	∞	180,000	11,100	.0000
J27	UN	450	∞	120,000	1,722,200	.0000
J28	UN	450	∞	110,000	1,357,100	.0000
J29	UN	450	∞	110,000	3,228,200	.0000
J30	UN	450	∞	90,000	12,794,000	.0000
J31	UN	450	∞	90,000	14,000,300*	.0000
J67	N	450	1	120,000	22,500	.0000
J68	N	450	1	100,000	37,700	.0000
J69	N	450	1	80,000	586,500	.0000
J70	N	450	1	60,000	10,535,600*	.0000
J71	N	450	1	70,000	574,000	.0000
J72	N	450	1	90,000	90,900	.0000
J73	N	450	1	70,000	2,021,300	.0000
J74	N	450	1	100,000	123,100	.0000
J75	N	450	∞	80,000	19,600	.0000
J76	N	450	∞	60,000	1,397,000	.0000
J77	N	450	∞	70,000	67,100	.0000
J78	N	450	∞	65,000	170,000	.0000
J79	N	450	∞	75,000	36,400	.0000
J80	N	450	∞	55,000	1,027,000	.0000
J81	N	450	∞	50,000	11,059,600*	.0000
J82	N	450	∞	55,000	315,600	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 7 (CONTINUED)

FATIGUE TEST DATA - THERMOLD J

Heat No.: D21144

Heat Treatment: Heat to 1850°F and hold 15 minutes. Air cool. Double temper 2 hours, plus 2 hours at 1000°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
J32	UN	1000	1	90,000	11,160,000*	.0055
J34	UN	1000	1	110,000	6,714,500	.0030
J35	UN	1000	1	100,000	6,483,000	.0030
J36	UN	1000	1	120,000	2,871,100	.0007
J37	UN	1000	1	140,000	1,130,700	.0007
J38	UN	1000	1	160,000	312,000	.0000
J39	UN	1000	1	180,000	109,500	.0000
J40	UN	1000	1	200,000	67,000	.0000
J41	UN	1000	∞	100,000	1,812,400	.0000
J42	UN	1000	∞	140,000	182,600	.0000
J43	UN	1000	∞	70,000	12,522,600*	.0005
J44	UN	1000	∞	80,000	3,987,300	.0002
J45	UN	1000	∞	180,000	4,000	.0000
J46	UN	1000	∞	160,000	44,600	.0000
J47	UN	1000	∞	150,000	59,800	.0000
J48	UN	1000	∞	120,000	465,800	.0000
J83	N	1000	1	50,000	8,111,500	.0004
J84	N	1000	1	110,000	34,200	.0000
J85	N	1000	1	90,000	140,900	.0000
J86	N	1000	1	100,000	57,700	.0000
J87	N	1000	1	60,000	3,538,500	.0000
J88	N	1000	1	50,000	10,011,100*	.0004
J89	N	1000	1	80,000	294,400	.0000
J90	N	1000	1	70,000	825,200	.0000
J91	N	1000	∞	70,000	38,000	.0000
J92	N	1000	∞	55,000	724,500	.0000
J93	N	1000	∞	50,000	3,033,200	.0000
J94	N	1000	∞	45,000	11,026,400*	.0000
J95	N	1000	∞	75,000	4,500	.0000
J96	N	1000	∞	65,000	94,900	.0000
J Spare-1	N	1000	∞	60,000	409,500	.0000
J Spare-2	N	1000	∞	70,000	8,800	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 8

FATIGUE TEST DATA - VASCOJET 1000

Heat No.: 31658

Heat Treatment: Preheat to 1000°F. Austenitize 1850°F. Air cool. Double temper 2 hours, plus 2 hours at 1025°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
V1	UN	75	1	120,000	150,700	.0000
V2	UN	75	1	100,000	300,000	.0000
V3	UN	75	1	80,000	4,006,000	.0000
V4	UN	75	1	70,000	15,616,200*	.0000
V5	UN	75	1	130,000	102,800	.0000
V6	UN	75	1	140,000	133,000	.0000
V7	UN	75	1	160,000	59,000	.0000
V8	UN	75	1	180,000	49,300	.0000
V9	UN	75	∞	80,000	17,797,800*	.0000
V10	UN	75	∞	100,000	382,100	.0000
V11	UN	75	∞	90,000	10,102,000*	.0000
V12	UN	75	∞	120,000	213,600	.0000
V13	UN	75	∞	140,000	79,600	.0000
V14	UN	75	∞	100,000	828,000	.0000
V15	UN	75	∞	100,000	193,500	.0000
V16	UN	75	∞	90,000	10,222,700*	
V49	N	75	1	100,000	66,000	.0000
V50	N	75	1	80,000	12,740,800*	.0000
V51	N	75	1	90,000	76,700	.0000
V52	N	75	1	90,000	8,591,100	.0000
V53	N	75	1	100,000	59,700	.0000
V54	N	75	1	120,000	15,500	.0000
V55	N	75	1	140,000	6,900	.0000
V56	N	75	1	95,000	48,500	.0000
V57	N	75	∞	80,000	32,400	.0000
V58	N	75	∞	70,000	181,100	.0000
V59	N	75	∞	50,000	12,171,600*	.0000
V60	N	75	∞	60,000	113,400	.0000
V61	N	75	∞	60,000	1,302,000	.0000
V62	N	75	∞	100,000	8,500	.0000
V63	N	75	∞	70,000	140,400	.0000
V64	N	75	∞	65,000	78,200	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 8 (CONTINUED)

FATIGUE TEST DATA - VASCOJET 1000

Heat No.: 31658

Heat Treatment: Preheat to 1000°F. Austenitize 1850°F. Air cool. Double temper 2 hours, plus 2 hours at 1025°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
V17	UN	800	1	100,000	15,113,000*	.0005
V18	UN	800	1	120,000	10,060,000*	.0005
V19	UN	800	1	140,000	1,870,900	.0001
V20	UN	800	1	150,000	2,619,500	.0002
V21	UN	800	1	200,000	96,000	.0000
V22	UN	800	1	180,000	525,400	.0000
V23	UN	800	1	130,000	10,758,500	.0005
V24	UN	800	1	220,000	71,400	.0000
V25	UN	800	∞	110,000	1,016,100	.0000
V26	UN	800	∞	130,000	193,200	.0000
V27	UN	800	∞	150,000	67,400	.0000
V28	UN	800	∞	120,000	767,000	.0000
V29	UN	800	∞	80,000	13,758,300*	.0002
V30	UN	800	∞	90,000	3,945,900	.0002
V31	UN	800	∞	160,000	36,700	.0000
V65	N	800	1	60,000	12,184,000*	.0003
V66	N	800	1	70,000	2,740,100	.0000
V67	N	800	1	80,000	1,628,700	.0000
V68	N	800	1	90,000	583,000	.0000
V69	N	800	1	100,000	130,900	.0000
V70	N	800	1	110,000	59,000	.0000
V71	N	800	1	95,000	401,700	.0000
V72	N	800	1	85,000	1,125,700	.0000
V73	N	800	∞	60,000	146,300	.0000
V74	N	800	∞	40,000	1,216,500	.0001
V75	N	800	∞	35,000	10,169,100*	.0004
V76	N	800	∞	70,000	5,700	.0000
V77	N	800	∞	45,000	5,364,500	.0003
V78	N	800	∞	70,000	18,100	.0000
V79	N	800	∞	65,000	40,700	.0000
V80	N	800	∞	40,000	3,057,800	.0002

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 8 (CONTINUED)

FATIGUE TEST DATA - VASCOJET 1000

Heat No.: 31658

Heat Treatment: Preheat to 1000°F. Austenitize 1850°F. Air cool. Double temper 2 hours, plus 2 hours at 1025°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
V33	UN	1000	1	140,000	1,271,300	.0000
V34	UN	1000	1	130,000	1,141,000	.0000
V35	UN	1000	1	160,000	267,400	.0006
V36	UN	1000	1	150,000	623,100	.0006
V37	UN	1000	1	120,000	4,334,300	.0022
V38	UN	1000	1	110,000	9,601,900	.0045
V39	UN	1000	1	110,000	10,300,000*	.0060
V40	UN	1000	1	180,000	252,700	.0003
V41	UN	1000	∞	100,000	1,081,200	.0002
V42	UN	1000	∞	80,000	3,124,300	.0000
V43	UN	1000	∞	70,000	6,386,000	.0000
V44	UN	1000	∞	90,000	1,953,300	.0000
V45	UN	1000	∞	60,000	6,231,000	.0000
V46	UN	1000	∞	60,000	10,080,500*	.0002
V47	UN	1000	∞	65,000	8,794,900	.0000
V48	UN	1000	∞	140,000	61,100	.0000
V81	N	1000	1	60,000	5,396,100	.0000
V82	N	1000	1	80,000	1,415,500	.0000
V83	N	1000	1	70,000	869,300	.0000
V84	N	1000	1	90,000	356,200	.0000
V85	N	1000	1	50,000	10,000,000*	.0006
V86	N	1000	1	120,000	5,900	.0000
V87	N	1000	1	110,000	40,000	.0000
V88	N	1000	1	100,000	173,700	.0000
V89	N	1000	∞	40,000	3,834,300	.0000
V90	N	1000	∞	35,000	10,140,000*	.0000
V91	N	1000	∞	50,000	297,900	.0000
V92	N	1000	∞	60,000	47,800	.0000
V93	N	1000	∞	70,000	11,000	.0000
V94	N	1000	∞	55,000	160,400	.0000
V95	N	1000	∞	45,000	1,007,600	.0000
V96	N	1000	∞	65,000	32,800	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 9

FATIGUE TEST DATA - PEERLESS 56

Heat No.: 44526

Heat Treatment: Heat to 1870°F in slightly reducing atmosphere. Hold 5 minutes. Air cool. Double temper 2 hours, plus 2 hours at 1050°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
P1	UN	75	1	150,000	282,300	.0000
P2	UN	75	1	130,000	1,817,300	.0000
P4	UN	75	1	170,000	94,800	.0000
P5	UN	75	1	120,000	16,575,000*	.0000
P6	UN	75	1	140,000	853,000	.0000
P7	UN	75	1	120,000	2,722,900	.0000
P8	UN	75	1	200,000	48,400	.0000
P9	UN	75	∞	120,000	97,500	.0000
P10	UN	75	1	230,000	7,700	.0000
P11	UN	75	∞	100,000	1,929,800	.0000
P12	UN	75	∞	110,000	51,100	.0000
P13	UN	75	∞	90,000	227,700	.0000
P14	UN	75	∞	90,000	659,100	.0000
P15	UN	75	∞	70,000	14,525,700	.0000
P16	UN	75	∞	160,000	17,800	.0000
P17	UN	75	∞	80,000	17,923,400*	.0000
P49	N	75	1	120,000	25,600	.0000
P50	N	75	1	100,000	66,100	.0000
P51	N	75	1	80,000	12,621,000*	.0000
P52	N	75	1	90,000	11,637,600*	.0000
P53	N	75	1	60,000	16,337,400*	.0000
P54	N	75	1	140,000	4,300	.0000
P55	N	75	1	110,000	182,200	.0000
P56	N	75	1	100,000	155,700	.0000
P57	N	75	∞	80,000	16,000	.0000
P58	N	75	∞	60,000	174,000	.0000
P59	N	75	∞	50,000	4,392,500	.0000
P60	N	75	∞	40,000	20,465,100*	.0000
P61	N	75	∞	70,000	40,900	.0000
P62	N	75	∞	60,000	3,822,100	.0000
P63	N	75	∞	50,000	126,000	.0000
P64	N	75	∞	70,000	42,000	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 9 (CONTINUED)

FATIGUE TEST DATA - PEERLESS 56

Heat No.: 44526

Heat Treatment: Heat to 1870°F in slightly reducing atmosphere. Hold 5 minutes. Air cool. Double temper 2 hours, plus 2 hours at 1050°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
P3	UN	800	1	110,000	1,707,000	.0000
P18	UN	800	1	80,000	12,222,100*	.0010
P19	UN	800	1	180,000	26,600	.0000
P20	UN	800	1	140,000	393,700	.0000
P21	UN	800	1	160,000	92,500	.0000
P22	UN	800	1	100,000	5,232,600	.0006
P23	UN	800	1	90,000	5,440,400	.0002
P24	UN	800	1	120,000	598,300	.0000
P25	UN	800	∞	110,000	80,600	.0000
P26	UN	800	∞	80,000	934,700	.0000
P27	UN	800	∞	120,000	56,900	.0000
P28	UN	800	∞	100,000	192,800	.0000
P29	UN	800	∞	130,000	24,400	.0000
P30	UN	800	∞	70,000	7,665,000	.0001
P31	UN	800	∞	60,000	10,000,000*	.0002
P32	UN	800	∞	90,000	1,060,600	.0000
P65	N	800	1	80,000	307,200	.0000
P66	N	800	1	75,000	462,000	.0000
P67	N	800	1	70,000	434,700	.0000
P68	N	800	1	60,000	2,510,200	.0002
P69	N	800	1	55,000	12,740,100*	.0010
P70	N	800	1	85,000	369,900	.0000
P71	N	800	1	90,000	66,400	.0000
P72	N	800	1	100,000	45,100	.0000
P73	N	800	∞	45,000	1,332,600	.0000
P74	N	800	∞	35,000	11,566,100*	.0000
P75	N	800	∞	50,000	379,700	.0000
P76	N	800	∞	70,000	11,100	.0000
P77	N	800	∞	55,000	94,200	.0000
P78	N	800	∞	65,000	12,500	.0000
P79	N	800	∞	60,000	68,800	.0000
P80	N	800	∞	40,000	10,580,000*	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 9 (CONTINUED)

FATIGUE TEST DATA - PEERLESS 56

Heat No.: 44526

Heat Treatment: Heat to 1870°F in slightly reducing atmosphere. Hold 5 minutes. Air cool. Double temper 2 hours, plus 2 hours at 1050°F.

Specimen No.	Notch	Test Temp. (°F)	Stress Ratio (A)	Maximum Stress	Cycles to Failure	Dynamic Creep**
P33	UN	1000	1	160,000	112,700	.0000
P34	UN	1000	1	120,000	552,600	.0000
P35	UN	1000	1	90,000	7,465,200	.0013
P36	UN	1000	1	85,000	5,080,600	.0016
P37	UN	1000	1	80,000	4,446,800	.0012
P38	UN	1000	1	70,000	6,757,700	.0014
P39	UN	1000	1	60,000	12,215,000*	.0024
P40	UN	1000	1	180,000	40,600	.0000
P41	UN	1000	∞	50,000	11,120,000*	.0000
P42	UN	1000	∞	80,000	701,100	.0008
P43	UN	1000	∞	120,000	64,800	.0000
P44	UN	1000	∞	90,000	232,900	.0000
P45	UN	1000	∞	100,000	274,900	.0000
P46	UN	1000	∞	60,000	9,684,100	.0003
P47	UN	1000	∞	110,000	127,900	.0000
P48	UN	1000	∞	70,000	2,542,900	.0000
P81	N	1000	1	60,000	3,283,300	.0000
P82	N	1000	1	50,000	5,784,700	.0000
P83	N	1000	1	80,000	59,000	.0000
P84	N	1000	1	70,000	847,600	.0000
P85	N	1000	1	50,000	8,435,200	.0008
P86	N	1000	1	45,000	10,000,100*	.0002
P87	N	1000	1	90,000	42,000	.0000
P88	N	1000	1	80,000	376,500	.0000
P89	N	1000	∞	35,000	9,856,500	.0000
P90	N	1000	∞	60,000	42,700	.0000
P91	N	1000	∞	40,000	2,267,400	.0000
P92	N	1000	∞	45,000	960,100	.0000
P93	N	1000	∞	50,000	213,500	.0000
P94	N	1000	∞	65,000	9,100	.0000
P95	N	1000	∞	60,000	19,700	.0000
P96	N	1000	∞	55,000	165,300	.0000

* Indicates specimen did not fail.

** Creep versus time data are given in Figures 68 through 73.

TABLE 10

TENSILE TEST DATA

Material	Specimen No.	Notch	Test Temp. (°F)	0.2% Y.S.	U.T.S.	% Elongation	% R. A.
D6AC	D97	UN	75	237,000	275,000	5.18	39.3
	D98	UN	75	238,000	265,000	5.19	36.4
	D99	UN	75	237,000	269,000	5.50	39.3
	D100	UN	450	176,000	259,000	10.2	43.8
	D101	UN	450	165,500	266,000	10.6	39.4
	D102	UN	450	175,500	255,000	10.6	37.4
	D103	UN	550	158,500	230,000	11.0	52.8
	D104	UN	550	166,000	239,000	12.2	57.3
	D105	UN	550	155,000	229,000	11.4	57.3
D6AC	D121	N	75		330,000		
	D122	N	75		334,000		
	D123	N	75		349,000		
	D124	N	450		362,000		
	D125	N	450		383,000		
	D126	N	450		387,000		
	D127	N	550		372,000		
	D128	N	550		369,000		
	D129	N	550		358,000		
LaBelle HT	H97	UN	75	234,000	289,000	8.42	39.3
	H98	UN	75	239,000	293,000	7.20	39.3
	H99	UN	75	237,000	291,000	7.20	42.9
	H100	UN	450	200,000	291,000	10.0	39.3
	H101	UN	450	197,000	298,000	9.70	38.5
	H102	UN	450	194,000	293,000	11.2	39.3
	H103	UN	550	183,000	277,000	13.6	38.3
	H104	UN	550	188,000	277,000	11.2	45.0
	H105	UN	550	187,000	279,000	13.3	42.8
LaBelle HT	H121	N	75		412,000		
	H122	N	75		412,000		
	H123	N	75		394,000		
	H124	N	450		389,000		
	H125	N	450		384,000		
	H126	N	450		394,000		
	H127	N	550		398,000		
	H128	N	550		391,000		
	H129	N	550		392,000		

TABLE 10 (CONTINUED)

TENSILE TEST DATA

Material	Specimen No.	Notch	Test Temp. (°F)	0.2% Y.S.	U.T.S.	% Elongation	% R.A.
Thermold J	J97	UN	75	273,000	338,000	5.82	22.7
	J98	UN	75	274,000	338,000	5.42	24.7
	J99	UN	75	277,000	337,000	5.82	28.8
	J100	UN	450	251,000	307,000	5.82	34.3
	J101	UN	450		307,500	5.82	31.3
	J102	UN	450	214,000	307,600	5.02	34.3
	J103	UN	1000	188,000	236,000	9.30	42.3
	J104	UN	1000	188,000	244,000	8.54	42.9
	J105	UN	1000	187,000	237,000	6.98	37.0
Thermold J	J121	N	75		427,000		
	J122	N	75		422,000		
	J123	N	75		426,000		
	J124	N	450		408,000		
	J125	N	450		408,000		
	J126	N	450		405,000		
	J127	N	1000		346,000		
	J128	N	1000		353,000		
	J129	N	1000		339,000		
Vasco Jet 1000	V97	UN	75	252,000	309,500	7.20	34.3
	V98	UN	75	249,000	309,500	7.60	39.3
	V99	UN	75	251,000	307,000	6.40	34.4
	V100	UN	800	194,000	256,000	7.35	39.3
	V101	UN	800		258,000	7.36	43.8
	V102	UN	800	206,000	263,000	6.20	43.7
	V103	UN	1000	181,000	231,000	9.70	50.6
	V104	UN	1000	176,000	227,000	7.75	49.3
	V105	UN	1000	176,000	229,000	9.70	51.3
Vasco Jet 1000	V121	N	75		438,000		
	V122	N	75		437,000		
	V123	N	75		432,000		
	V124	N	800		356,000		
	V125	N	800		381,000		
	V126	N	800		391,000		
	V127	N	1000		332,000		
	V128	N	1000		332,000		
	V129	N	1000		336,000		

TABLE 10 (CONTINUED)

TENSILE TEST DATA

Material	Specimen No.	Notch	Test Temp. (°F)	0.2% Y.S.	U.T.S.	% Elongation	% R. A.
Peerless 56	P97	UN	75	254,000	299,000	5.6	23.9
	P98	UN	75	249,000	298,500	5.2	28.9
	P99	UN	75	252,000	295,000	5.6	28.9
	P100	UN	800	202,000	251,000	7.6	45.0
	P101	UN	800	203,000	249,000	6.6	42.9
	P102	UN	800	199,000	256,000	6.20	43.0
	P103	UN	1000	182,000	217,900	8.92	45.8
	P104	UN	1000	171,500	212,000	8.13	44.9
	P105	UN	1000	172,000	216,000	9.30	50.2
Peerless 56	P121	N	75		394,000		
	P122	N	75		404,000		
	P123	N	75		404,000		
	P124	N	800		368,000		
	P125	N	800		368,000		
	P126	N	800		365,000		
	P127	N	1000		327,000		
	P128	N	1000		325,000		
	P129	N	1000		324,000		

TABLE 11

STRESS RUPTURE DATA

Material	Specimen No.	Notch	Test Temp. (^{o}F)	Stress	% Elongation	% R.A.	Life (Hours)
D6AC	D106	UN	450	250,000	10.6	17.9	0.5
	D107	UN	450	238,000	7.2	37.4	30 sec.
	D108	UN	450	233,000	8.5	33.5	97.4
	D109	UN	450	235,000	7.6	33.4	9.4
	D110	UN	450	234,000	Discontinued @ 1063.0		
	D111	UN	550	225,000	8.67	43.7	30 sec.
	D112	UN	550	218,000	7.05	45.7	0.5
	D113	UN	550	205,000	6.45	28.4	69.1
	D114	UN	550	210,000	Discontinued @ 1063.0		
	D115	UN	550	214,000	6.99	48.0	26.6
D6AC	D130	N	450	360,500			1.0
	D131	N	450	355,000			0.0166
	D132	N	450	350,000			5.4
	D133	N	450	345,000			24.7
	D134	N	450	340,000			43.2
	D135	N	550	306,600			44.3
	D136	N	550	315,000			6.4
	D137	N	550	310,000			3.6
	D138	N	550	300,000			689.5
	D139	N	550	308,000			30.1
LaBelle HT	H106	UN	450	289,000	12.5	28.9	0.05
	H107	UN	450	270,000	4.7	Discontinued @ 303.8	
	H108	UN	450	283,000	12.8	16.5	1.9
	H109	UN	450	279,000	8.5	Discontinued @ 1174.3	
	H110	UN	450	282,000	9.4	Discontinued @ 1178.1	
	H111	UN	550	270,000	12.5	37.2	0.3
	H112	UN	550	264,000	9.4	37.8	18.4
	H113	UN	550	266,000	12.7	36.6	154.1
	H114	UN	550	268,000	12.3	33.4	0.05
	H115	UN	550	267,000	11.7	42.7	0.4
LaBelle HT	H130	N	450	379,000			B.O.L.
	H131	N	450	355,750			0.6
	H132	N	450	346,500			0.4
	H133	N	450	341,300	Discontinued @ 786.0		
	H134	N	450	345,000			510.0
	H135	N	550	363,000			83.0
	H136	N	550	368,000			B.O.L.
	H137	N	550	363,500			14.0
	H138	N	550	363,600			3.8
	H139	N	550	363,250			0.0166

TABLE 11 (CONTINUED)

STRESS RUPTURE DATA

Material	Specimen No.	Notch	Test Temp. (°F)	Stress	% Elongation	% R.A.	Life (Hours)
Thermold J	J106	UN	450	295,000	0.9	Discontinued	@ 799.7
	J107	UN	450	300,000	2.3	Discontinued	@ 1149.7
	J108	UN	450	305,000	3.3	31.4	B.O.L.
	J109	UN	450	302,000	2.9	Discontinued	@ 1145.5
	J110	UN	450	303,000	2.3	Discontinued	@ 1500.2
	J111	UN	800	252,500	4.3	15.0	271.7
	J112	UN	800	260,000	3.77	6.5	253.0
	J113	UN	800	270,000	5.7	22.6	61.6
	J114	UN	800	275,000	5.7	35.4	2.0
	J115	UN	800	272,500	6.84	33.9	0.3
	J116	UN	1000	210,000	6.1	38.0	0.1
	J117	UN	1000	162,500	2.74	5.0	8.0
	J118	UN	1000	146,000	1.75	4.0	11.8
	J119	UN	1000	130,000	4.05	5.0	26.5
	J120	UN	1000	118,000	2.46	4.5	34.7
Thermold J	J130	N	450	381,224			0.1
	J131	N	450	373,000		Discontinued	@ 1626.4
	J132	N	450	377,000		Discontinued	@ 1429.7
	J133	N	450	380,000		Discontinued	@ 837.3
	J134	N	450	388,060		Discontinued	@ 400.0
	J135	N	800	334,800			1.8
	J136	N	800	330,000			6.6
	J137	N	800	324,000			19.1
	J138	N	800	314,000			35.3
	J139	N	800	308,000			62.9
	J140	N	1000	264,100			0.0166
	J141	N	1000	258,000			0.0333
	J142	N	1000	255,000			0.2
	J143	N	1000	235,000			0.4
	J144	N	1000	200,000			1.0
Vasco Jet 1000	V107	UN	550	275,000	1.9	Discontinued	@ 1181.9
	V108	UN	550	280,000	4.3	Discontinued	@ 1102.8
	V109	UN	550	280,000	7.15	36.7	B.O.L.
	V110	UN	550	277,170	1.8	Discontinued	@ 1457.6
	V111	UN	550	265,000	2.1	Discontinued	@ 1181.9
	V106	UN	800	251,000	6.7	36.2	276.3
	V112	UN	800	254,000	5.9	9.5	346.0
	V113	UN	800	257,000	9.15	38.2	2.0
	V114	UN	800	256,000	6.54	38.4	173.6
	V115	UN	800	256,600	6.84	38.4	0.2
	V116	UN	1000	222,000	8.2	48.0	30 sec.
	V117	UN	1000	217,000	9.8	48.0	B.O.L.
	V118	UN	1000	200,000	7.5	39.8	1.0
	V119	UN	1000	180,000	4.9	17.1	4.1
	V120	UN	1000	150,000	2.59	7.54	26.2

TABLE 11 (CONTINUED)

STRESS RUPTURE DATA

Material	Specimen No.	Notch	Test Temp. (°F)	Stress	% Elongation	% R. A.	Life (Hours)
Vasco Jet 1000	V130	N	550	381,000			1.0
	V131	N	550	373,000			Discontinued @ 1625.7
	V132	N	550	378,000			Discontinued @ 1505.1
	V133	N	550	380,000			Discontinued @ 835.0
	V134	N	550	380,800			B.O.L.
	V135	N	800	292,100			101.1
	V136	N	800	298,000			98.4
	V137	N	800	317,800			14.2
	V138	N	800	325,000			107.0
	V139	N	800	326,000			94.1
	V140	N	1000	288,555			0.5
	V141	N	1000	275,000			0.15
	V142	N	1000	248,400			0.8
	V143	N	1000	240,000			0.6
	V144	N	1000	220,000			0.7
Peerless 56	P106	UN	550	270,000	5.3	33.9	15 sec.
	P107	UN	550	263,000	3.3		Discontinued @ 1181.5
	P108	UN	550	266,000	2.4		Discontinued @ 1152.5
	P109	UN	550	268,000	3.6		Discontinued @ 1146.9
	P110	UN	550	269,000	3.6		Discontinued @ 1504.3
	P111	UN	800	243,000	8.4	33.5	2.3 to 7.0 hrs.
	P112	UN	800	238,000	9.65	28.5	260.5
	P113	UN	800	240,000	9.1	36.0	23.3
	P114	UN	800	239,000	6.15	25.5	88.7
	P115	UN	800	241,000	8.15	27.5	34.9
	P116	UN	1000	185,000	3.9	7.0	4.4
	P117	UN	1000	175,000	2.7	6.5	5.8
	P118	UN	1000	162,000	2.2	4.5	11.4
	P119	UN	1000	145,000	0.92	2.5	27.7
	P120	UN	1000	135,000	0.92	4.03	33.0
	P130	N	550	377,100			0.0166
	P131	N	550	372,000			B.O.L.
	P133	N	550	358,000			0.1
	P136	N	550	340,000			Discontinued @ 1629.8
	P134	N	550	350,000			Discontinued @ 1433.0
	P135	N	800	328,560			21.3
	P132	N	800	332,000			17.7
	P137	N	800	340,000			14.3
	P138	N	800	360,000			B.O.L.
	P139	N	800	315,000			62.5
	P140	N	1000	276,200			0.0333
	P141	N	1000	270,000			0.3
	P144	N	1000	258,000			0.5
	P145	N	1000	245,000			0.5
	P146	N	1000	225,000			1.1

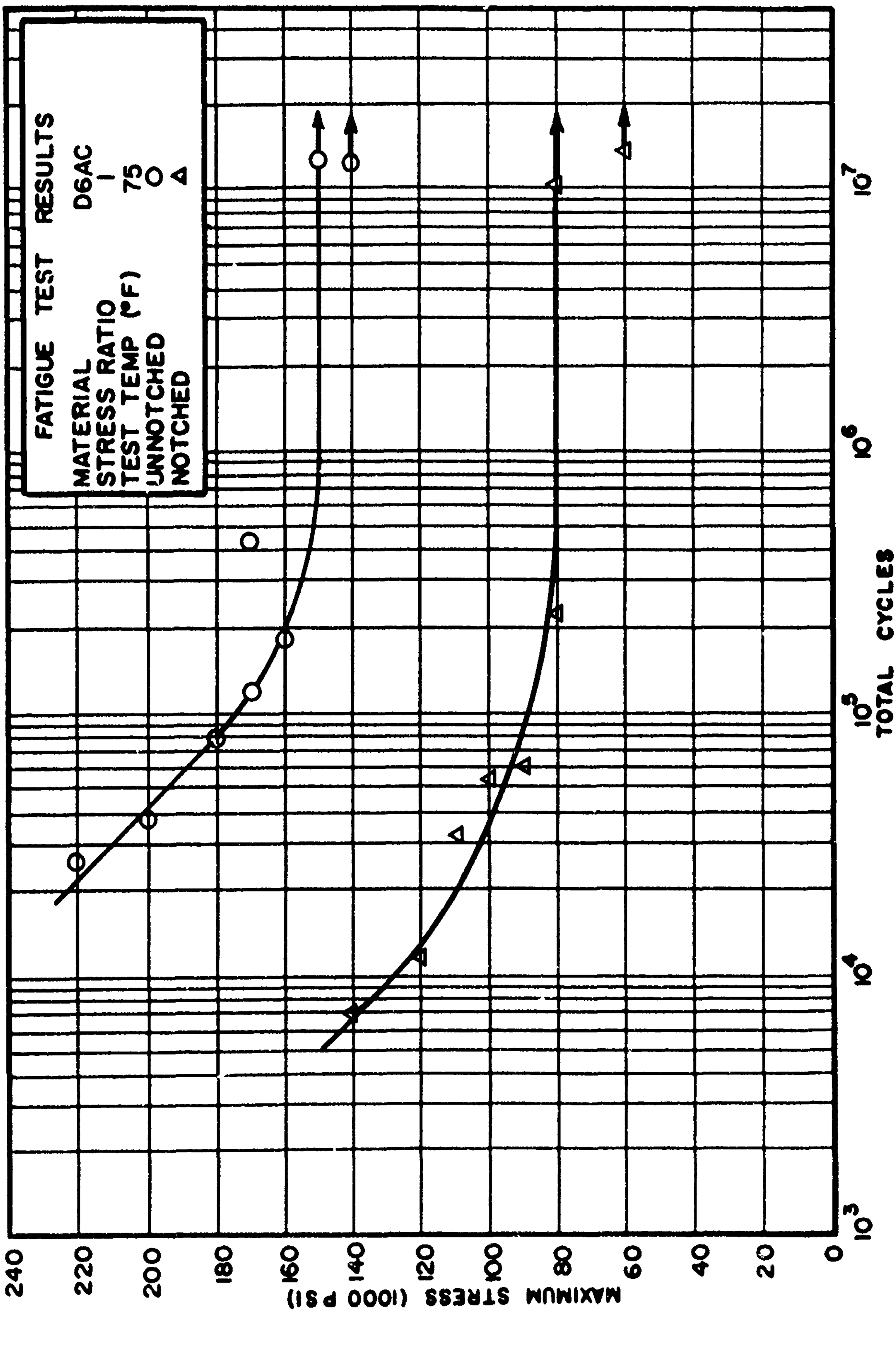


FIGURE 21 S-N DIAGRAMS: D6AC, 75°F, A=1

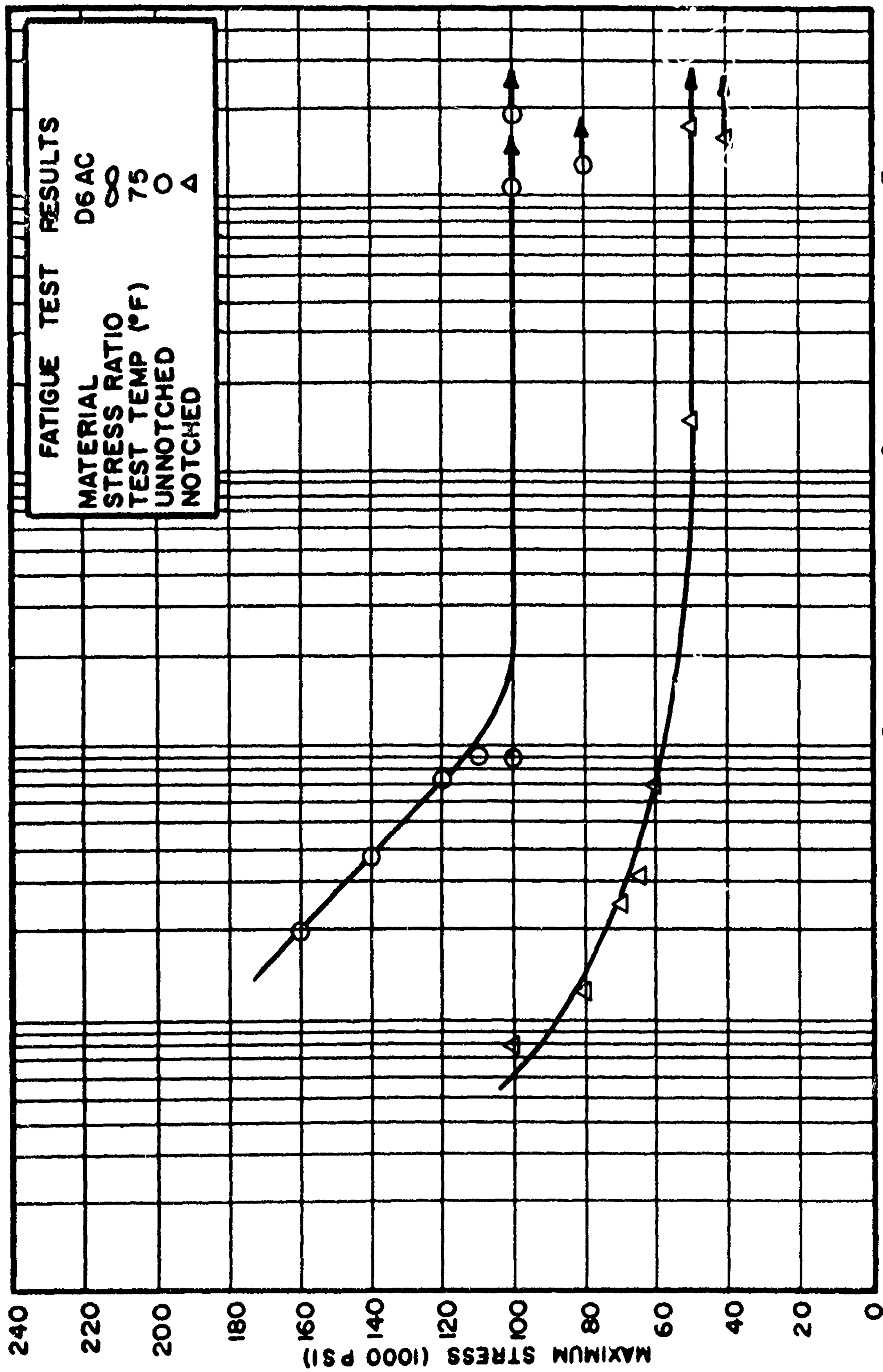


FIGURE 22 S-N DIAGRAMS: D6AC, 75°F, A= ∞

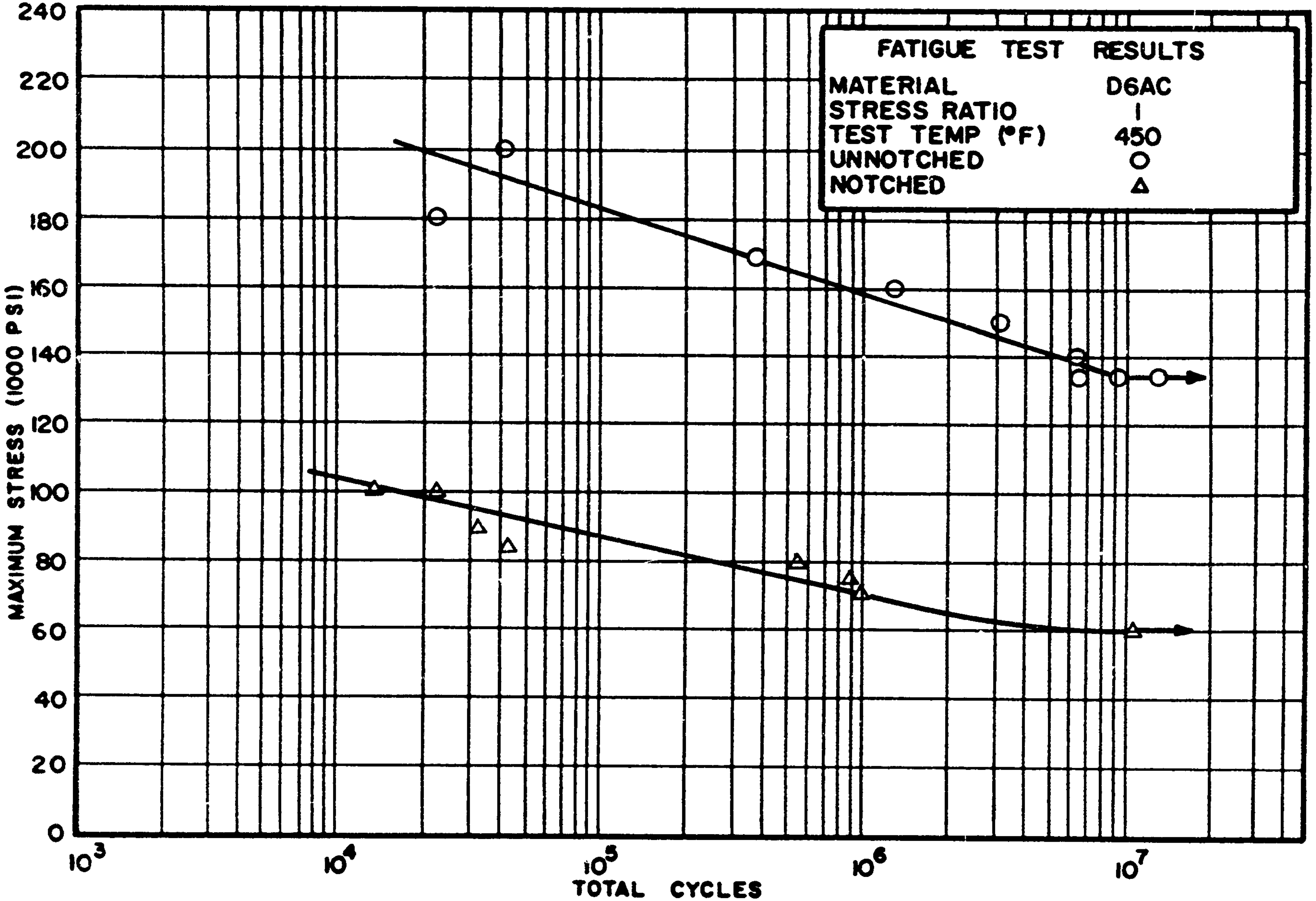


FIGURE 23 S-N DIAGRAMS: D6AC, 450°F, A=1

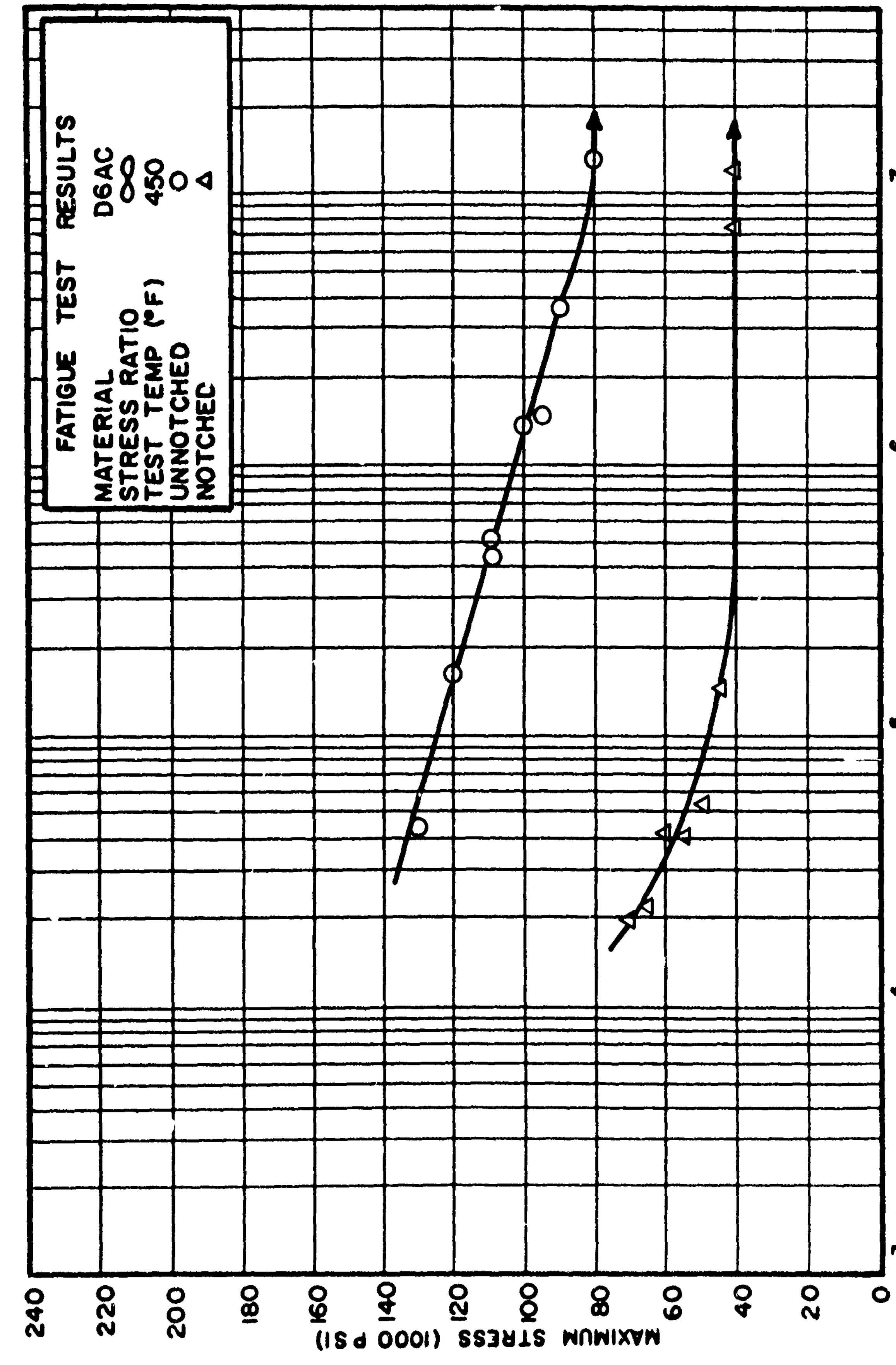


FIGURE 24 S-N DIAGRAMS: D6AC, 450°F, A= ∞

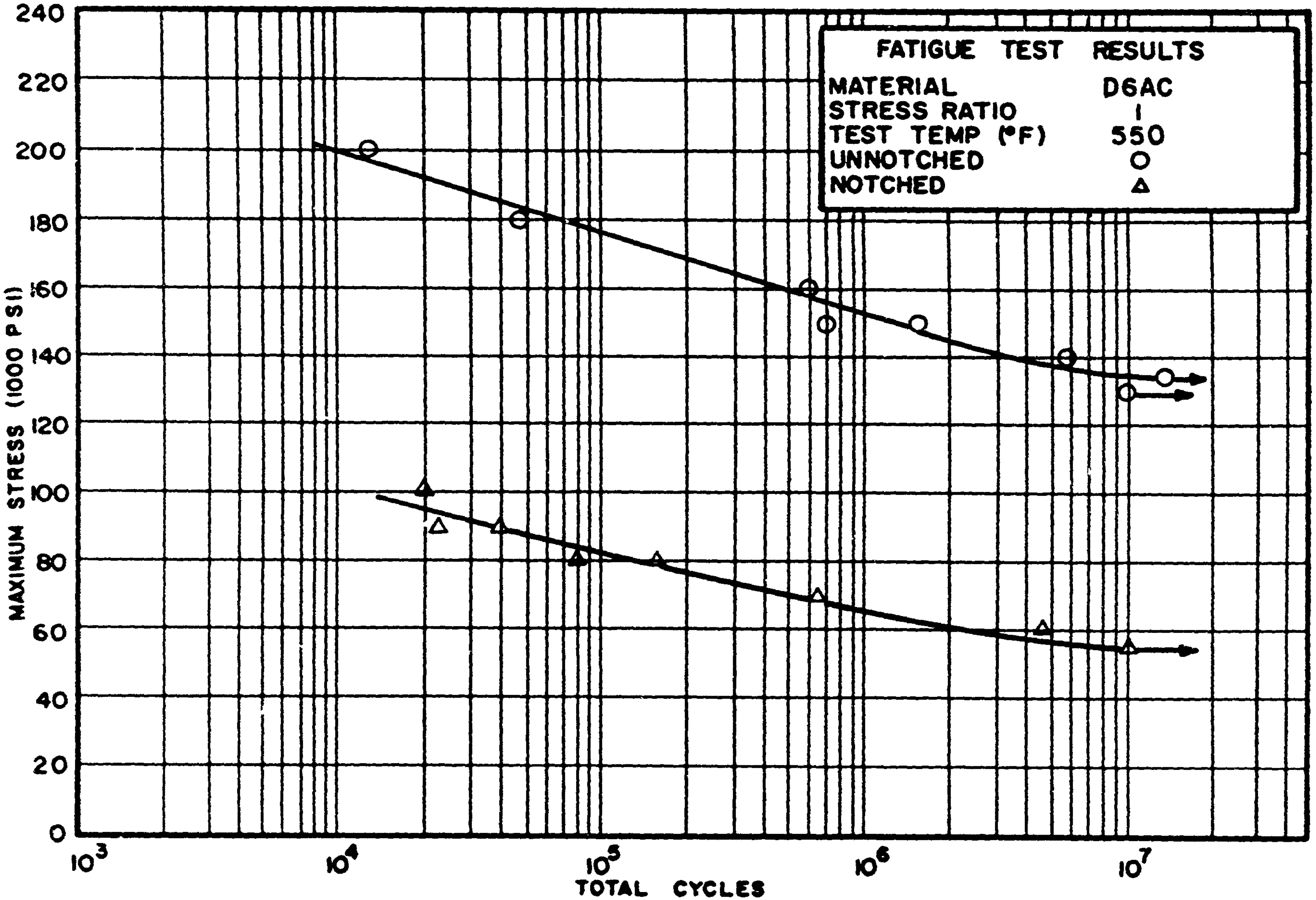


FIGURE 25 S-N DIAGRAMS: D6AC, 550°F, A=1

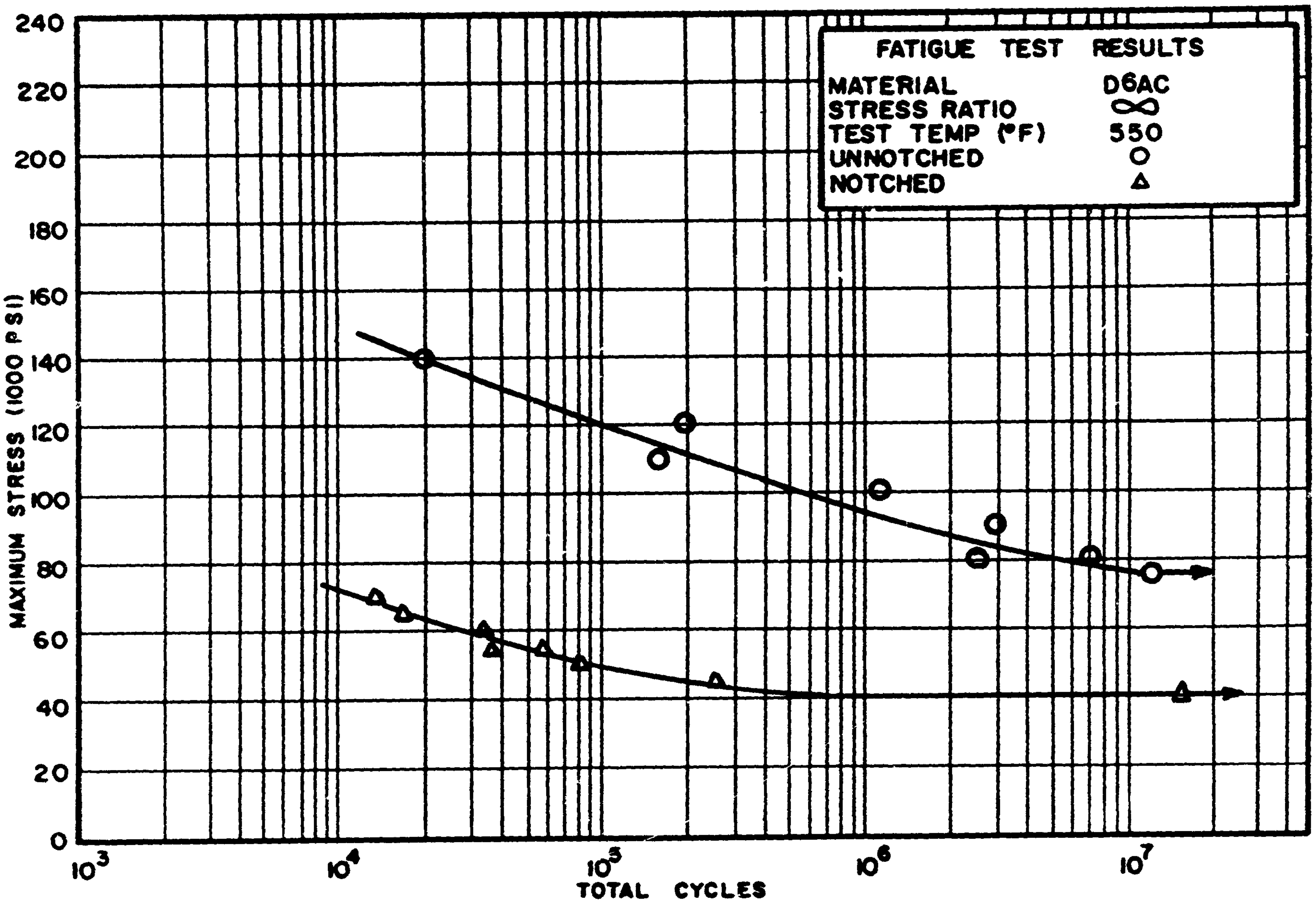


FIGURE 26 S-N DIAGRAMS: D6AC, 550°F, A= ∞

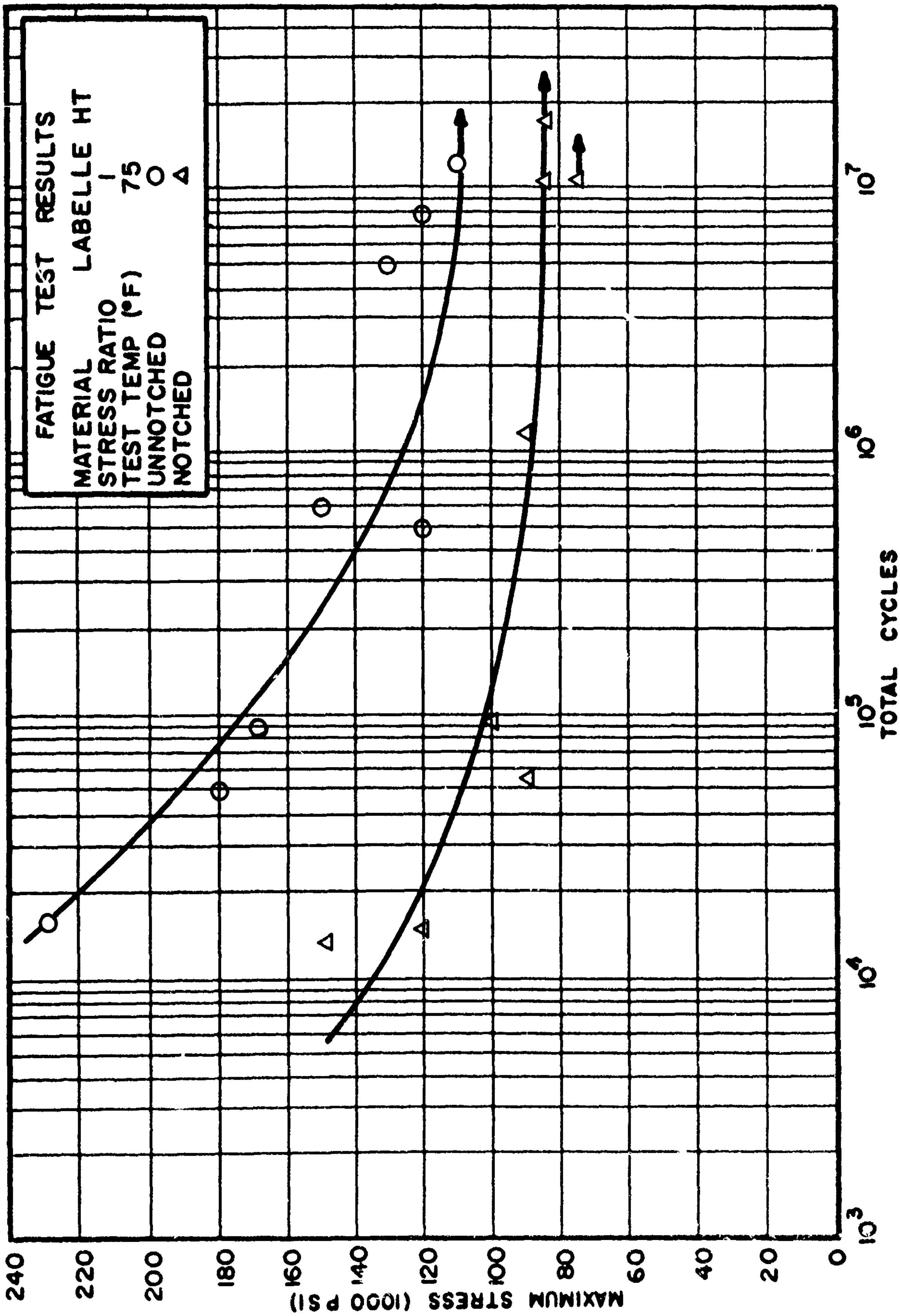


FIGURE 27 S-N DIAGRAMS: LABELLE HT, 75°F, A= 1

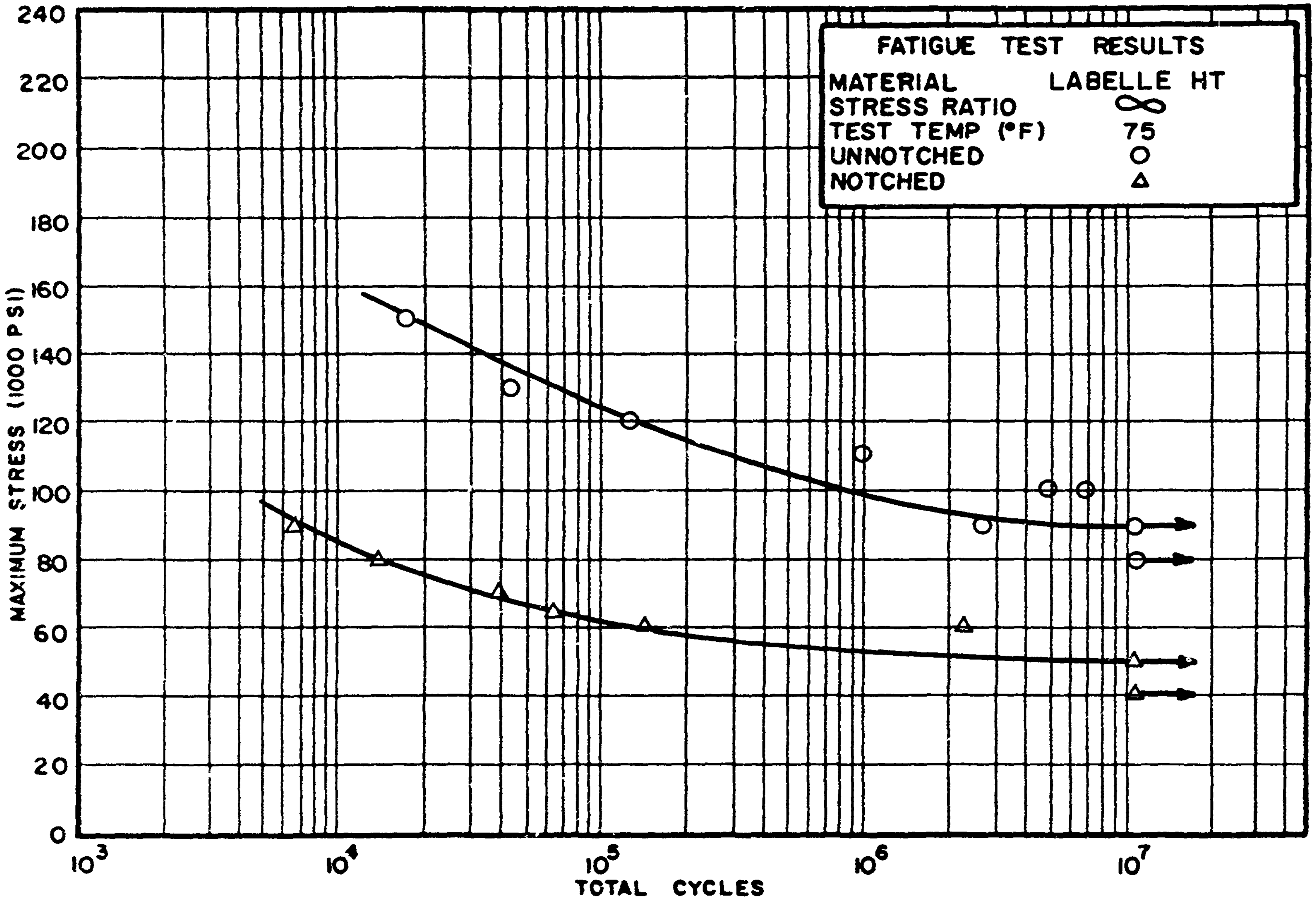


FIGURE 28 S-N DIAGRAMS: LABELLE HT, 75°F, A= ∞

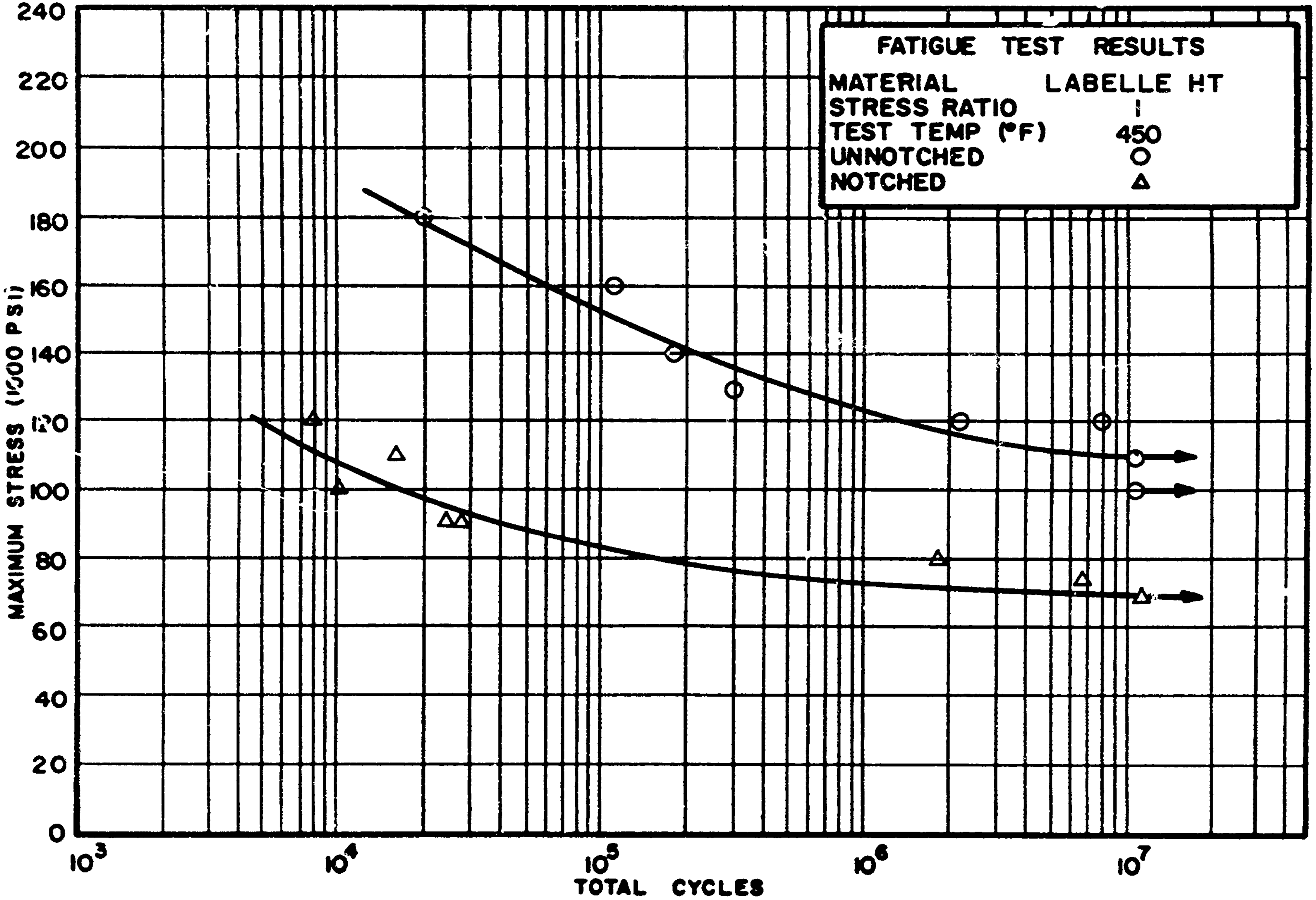


FIGURE 29 S-N DIAGRAMS : LABELLE HT, 450°F, A= 1

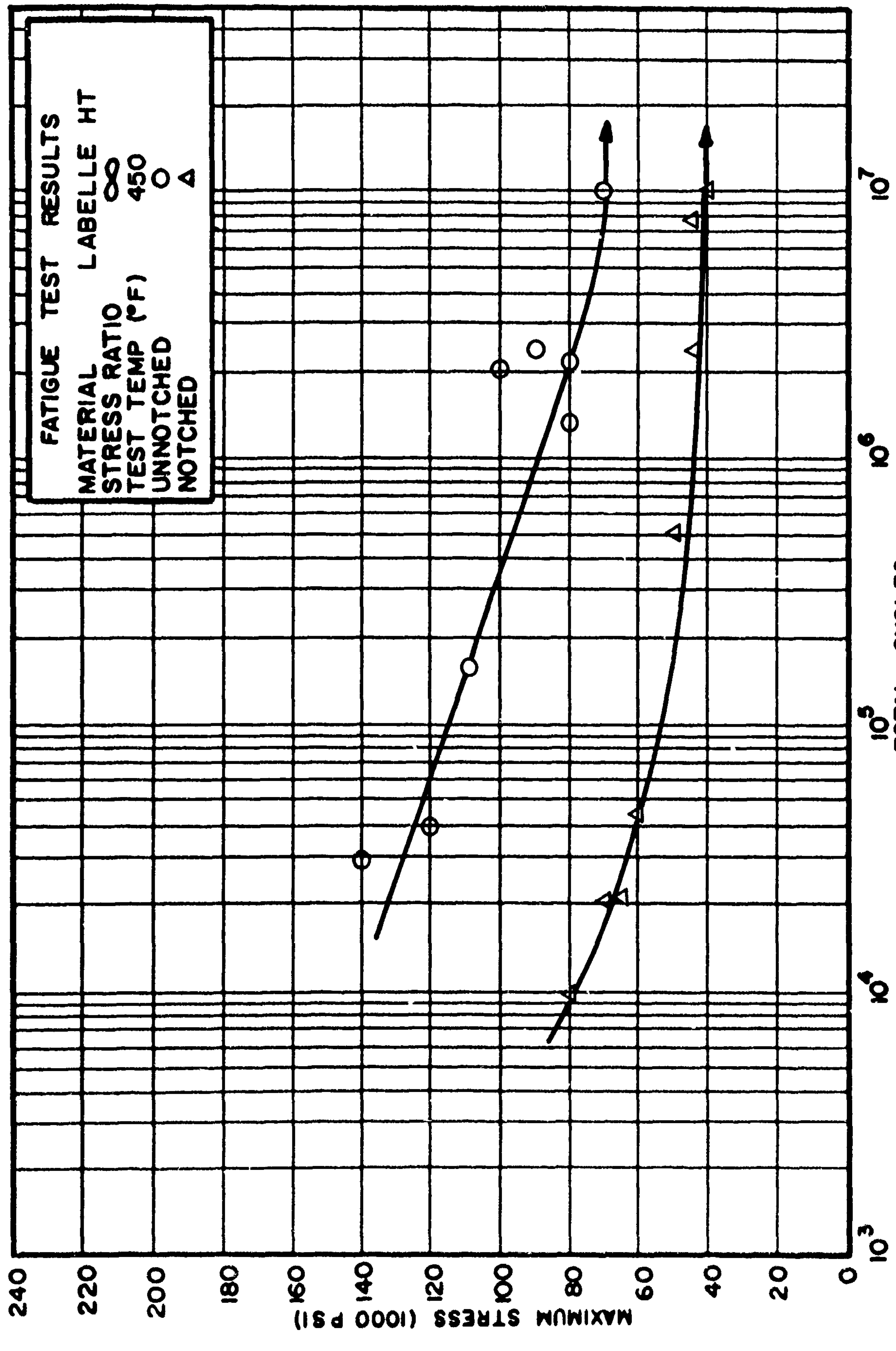


FIGURE 30 S-N DIAGRAMS: LABELLE HT, 450°F, A= ∞

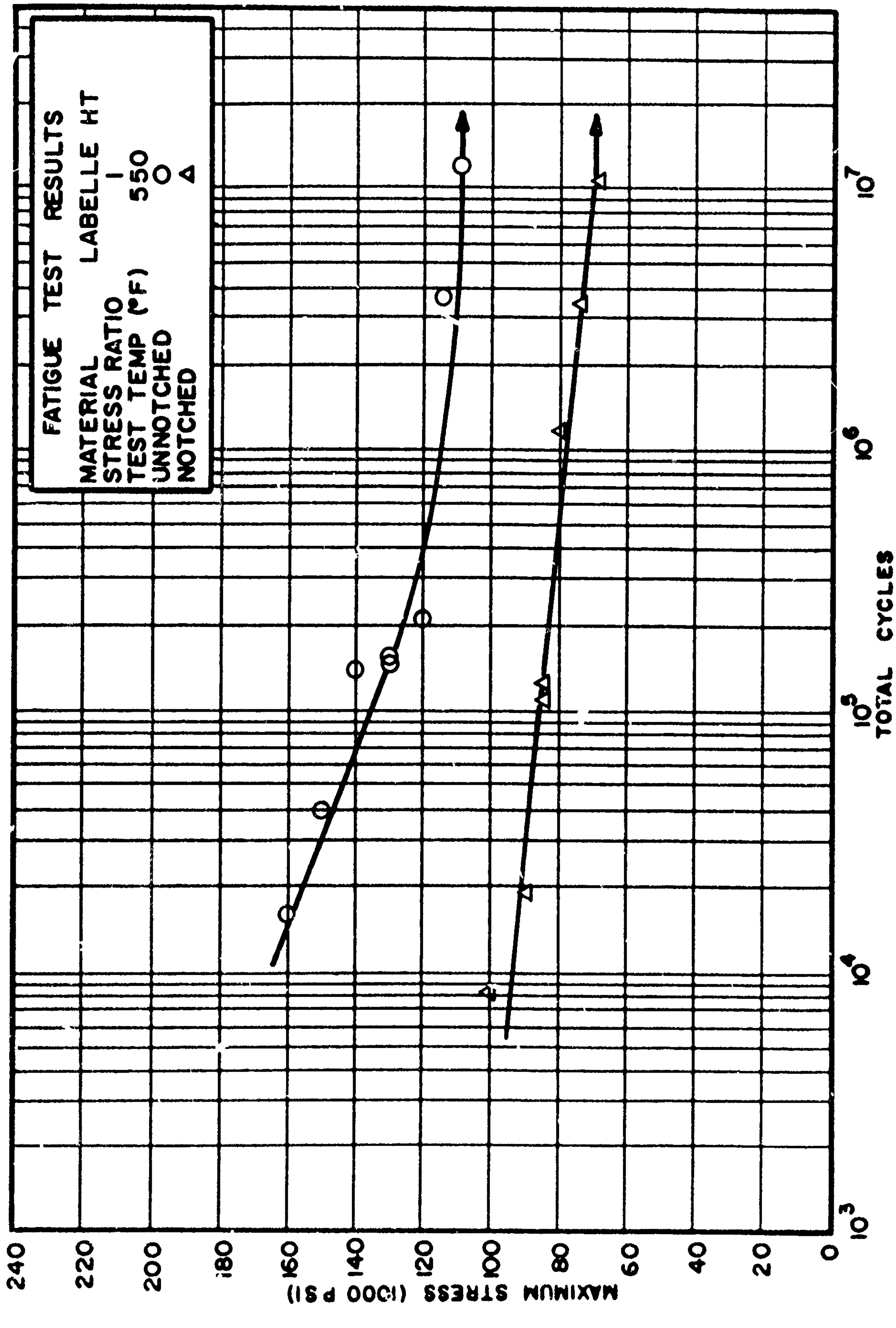


FIGURE 31 S-N DIAGRAMS: LABELLE HT, 550°F, A= 1

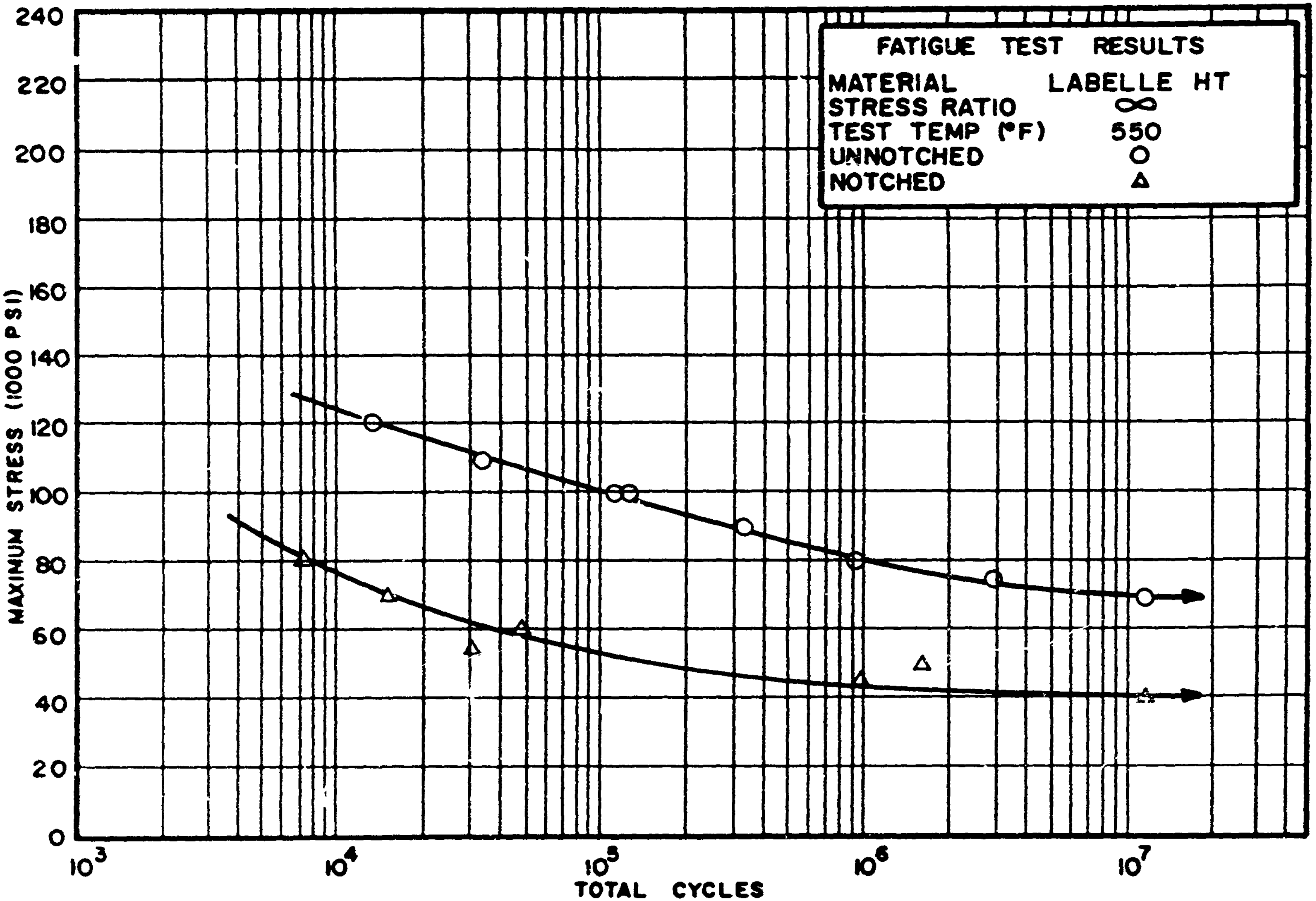


FIGURE 32 S-N DIAGRAMS: LABELLE HT, 550°F, A= ∞

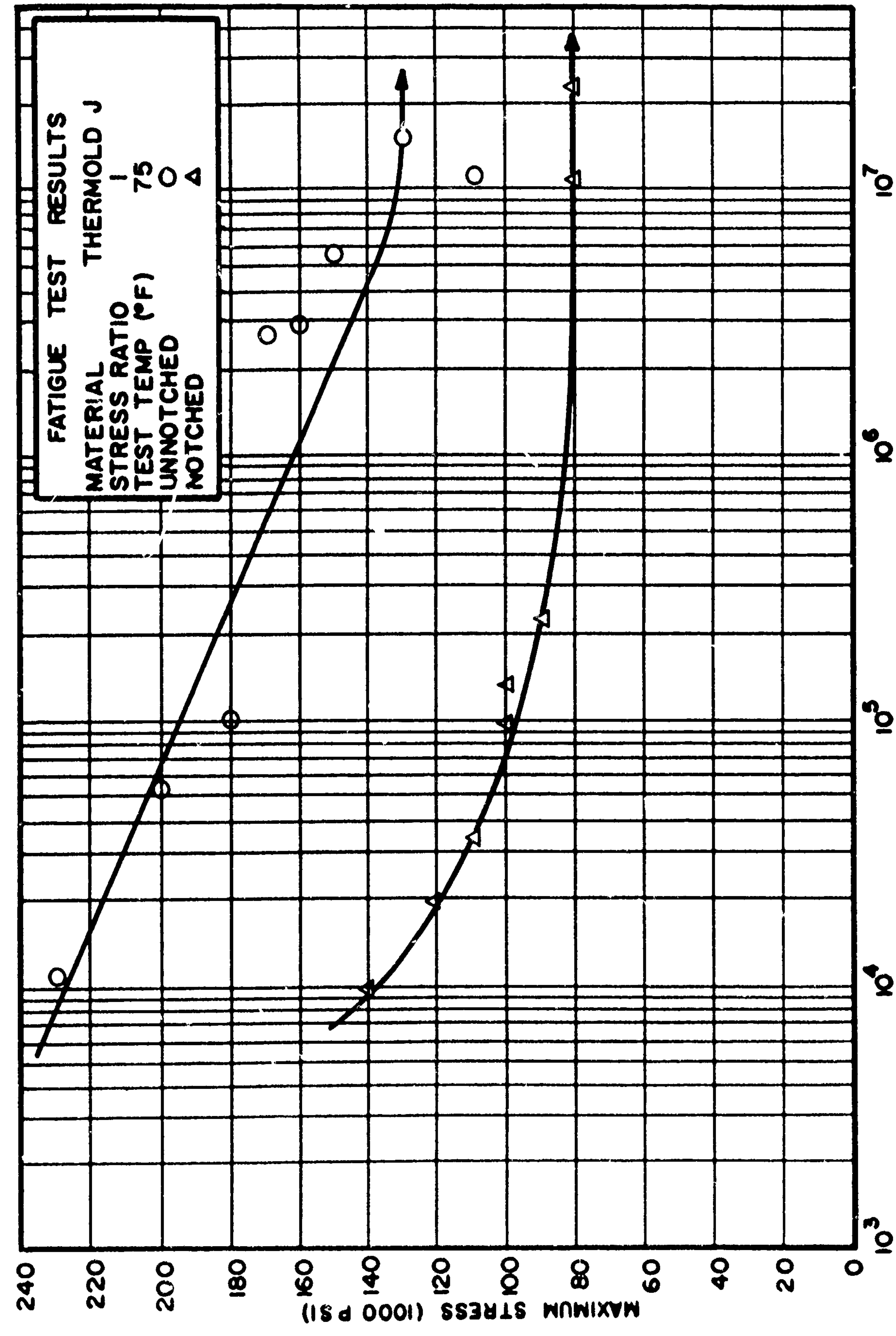


FIGURE 33 S-N DIAGRAMS: THERMOLD J, 75°F, A = 1

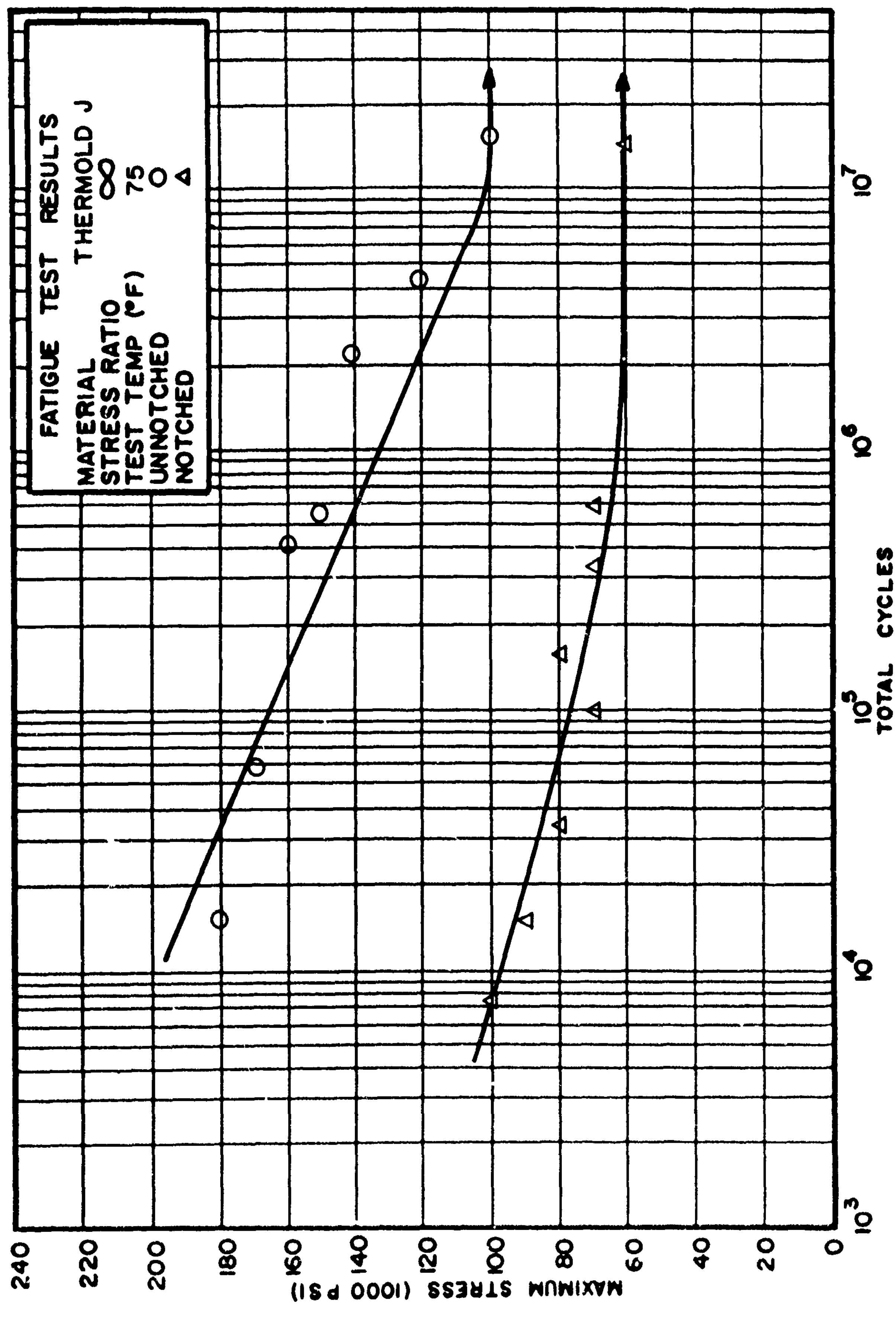


FIGURE 34 S-N DIAGRAMS: THERMOLD J, 75°F, A= ∞

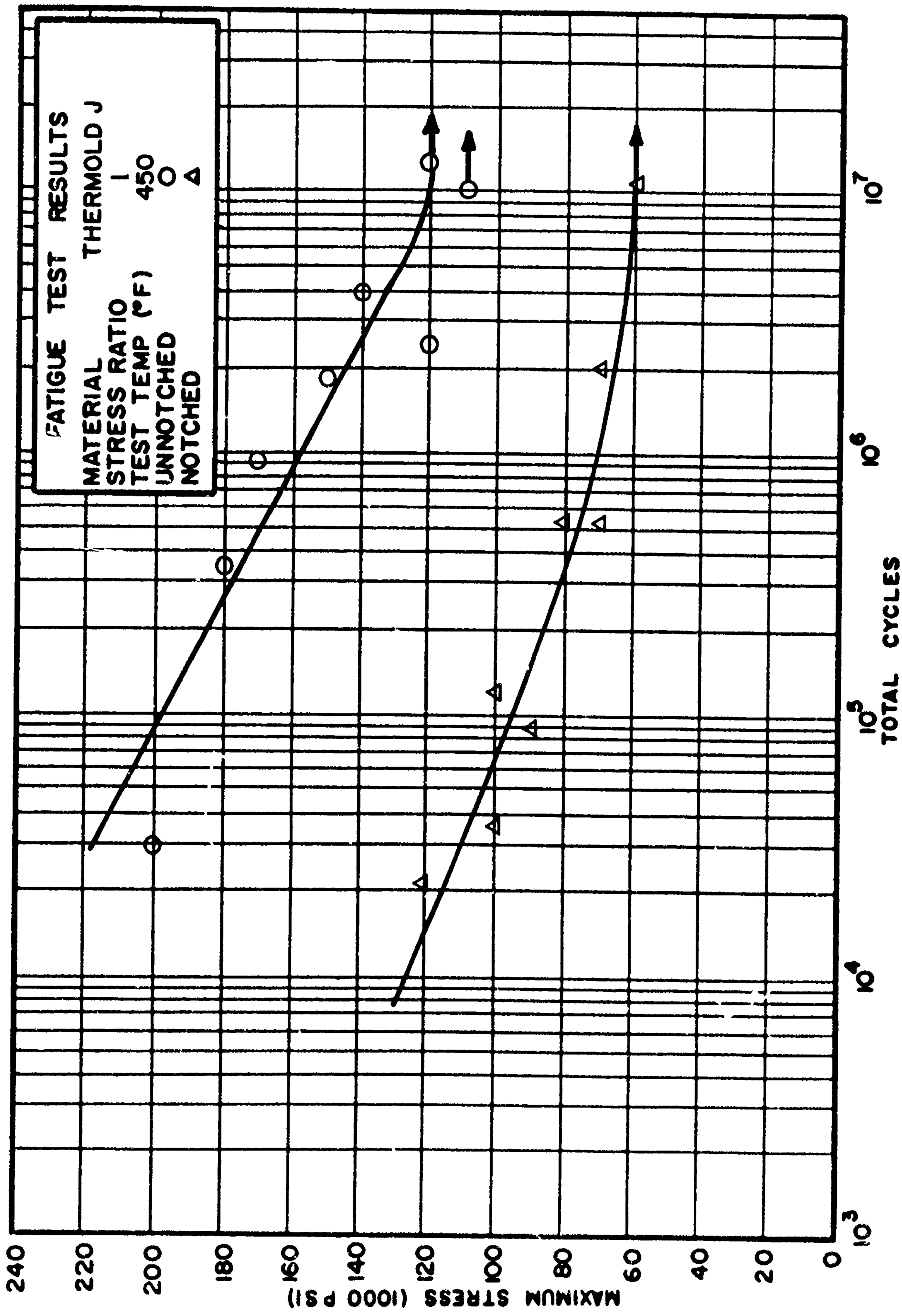


FIGURE 35 S-N DIAGRAMS: THERMOLD J, 450°F, A= 1

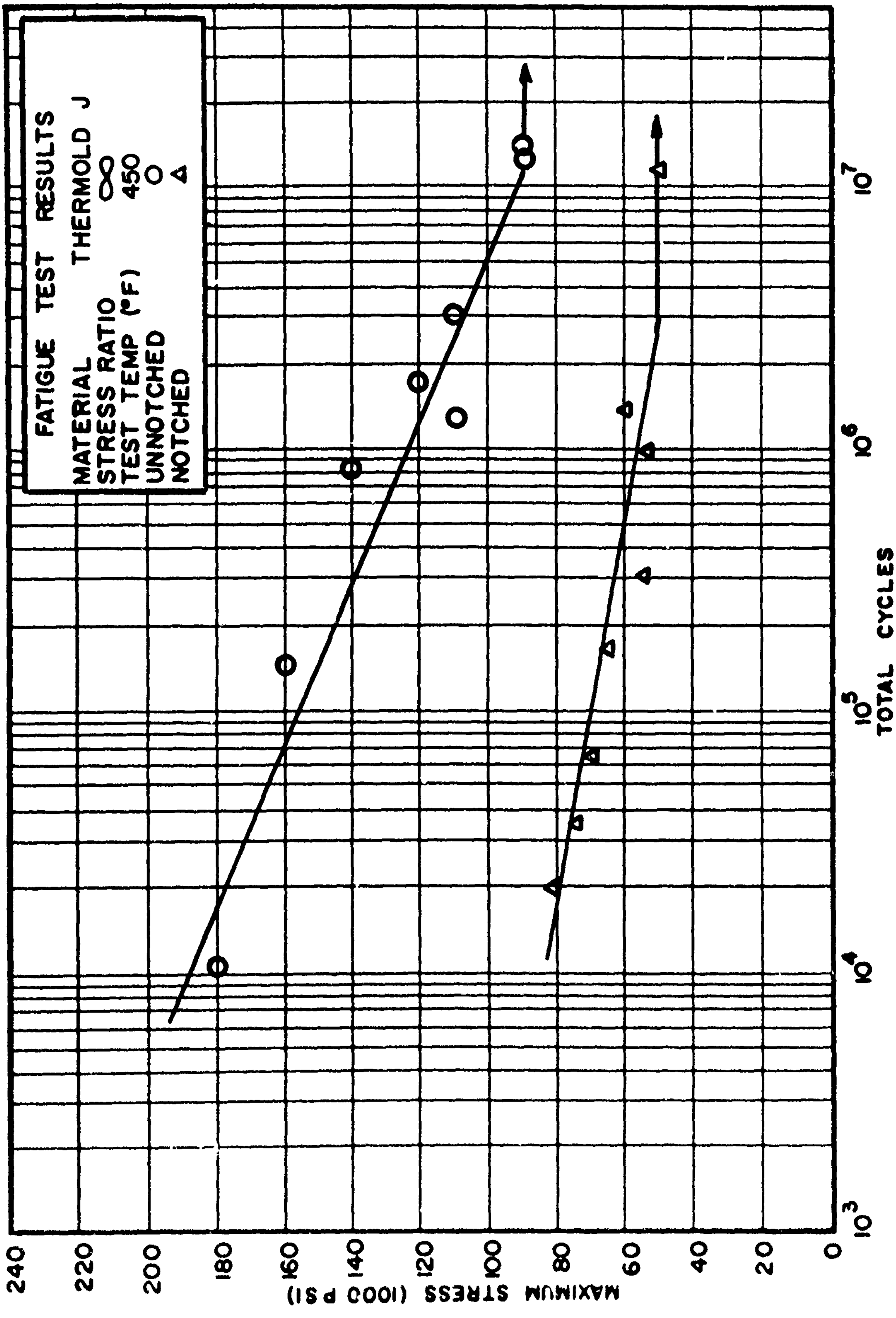


FIGURE 36 S-N DIAGRAMS: THERMOLD J, 450°F, A = ∞

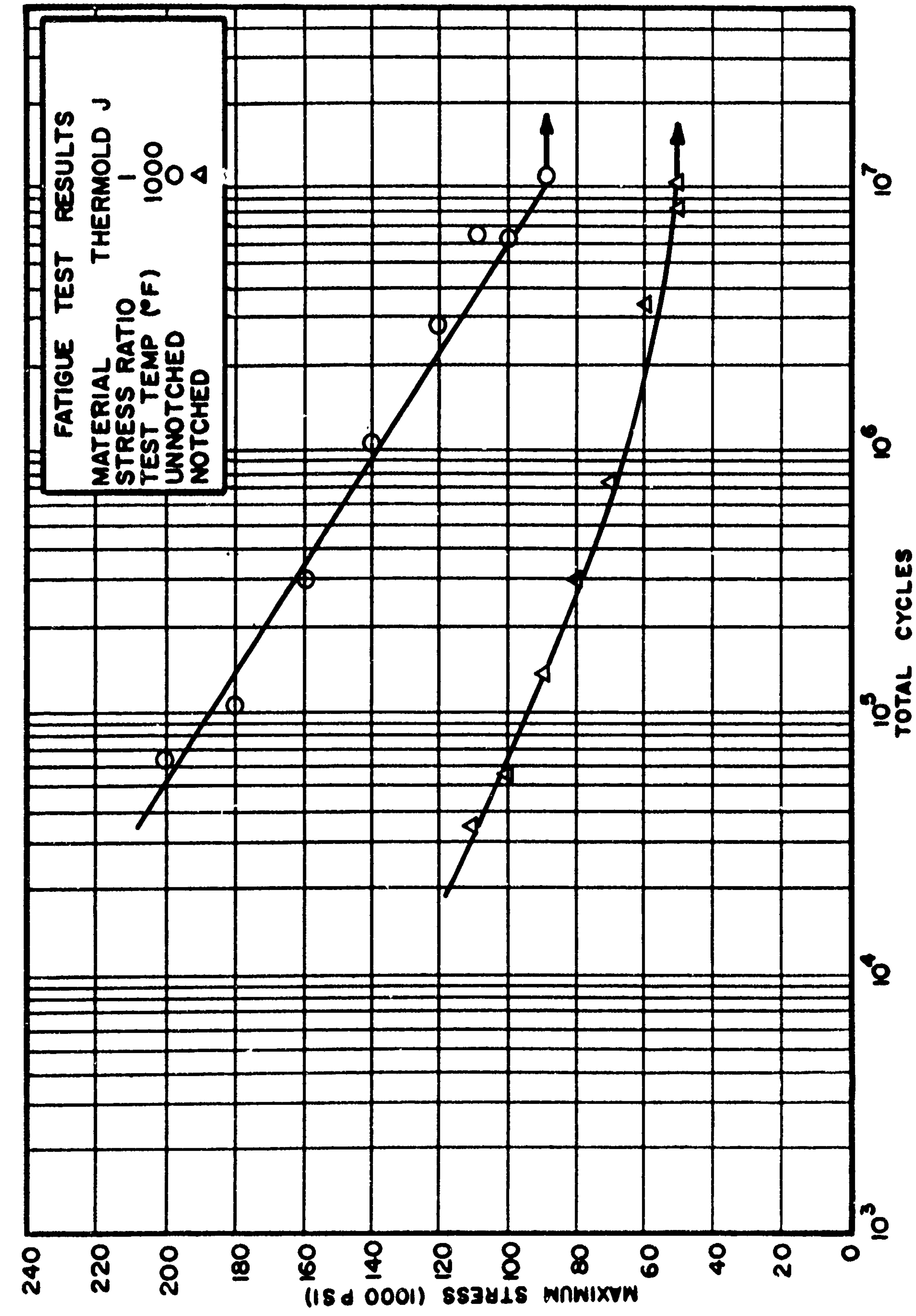


FIGURE 37 S-N DIAGRAMS: THERMOLD J, 1000°F, A= 1

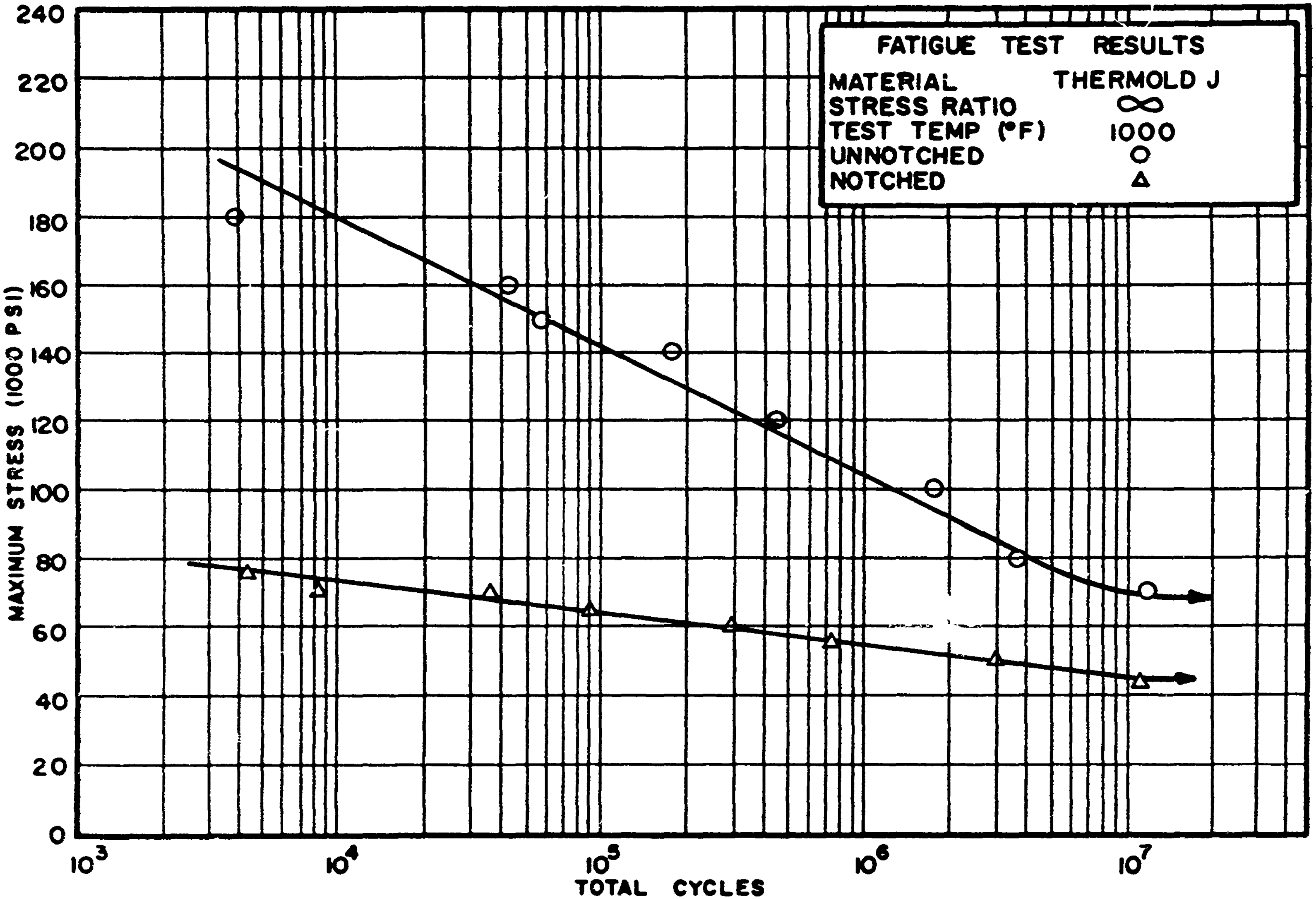


FIGURE 38 S-N DIAGRAMS : THERMOLD J, 1000°F, A= ∞

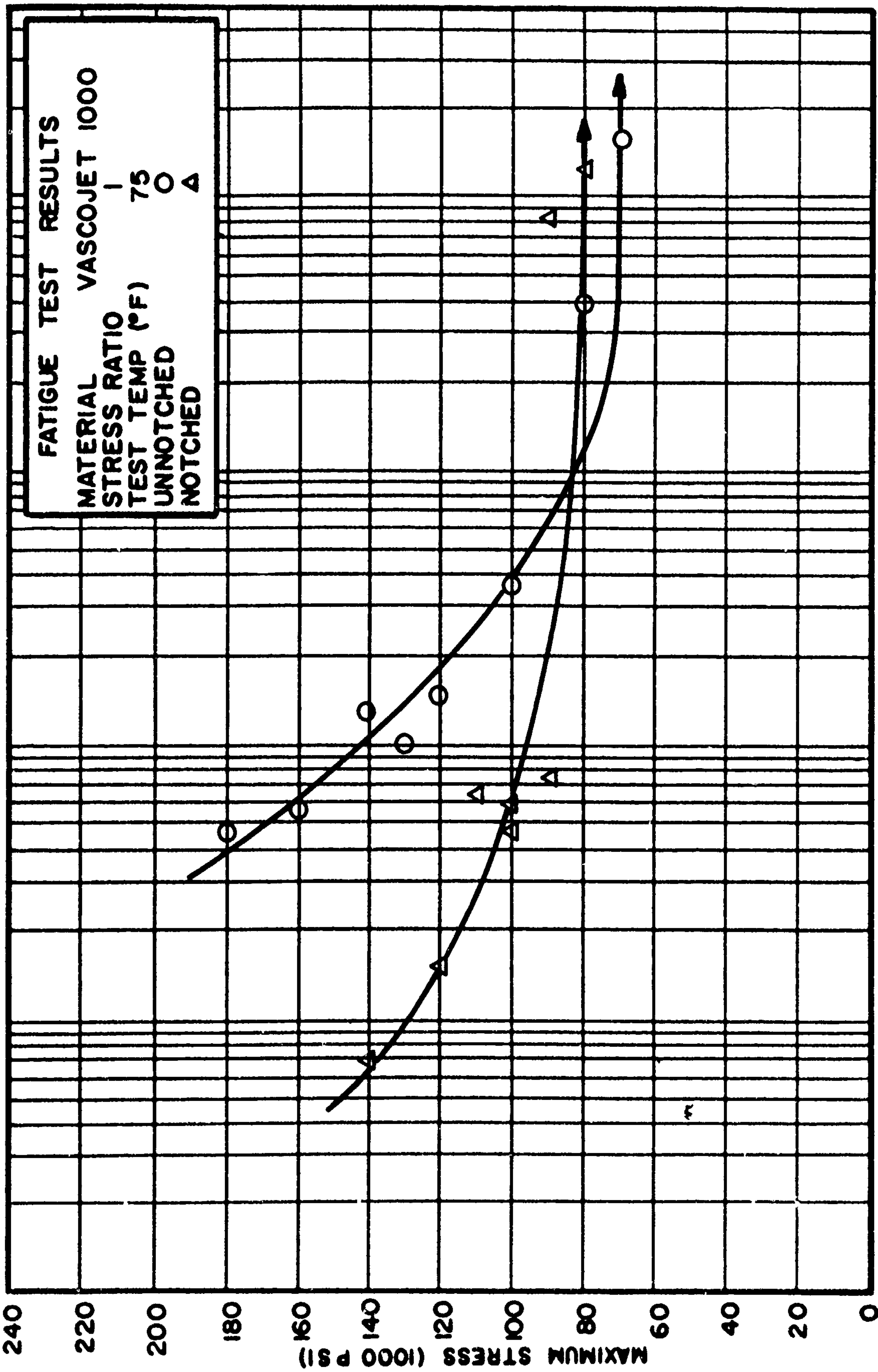


FIGURE 39 S-N DIAGRAMS: VASCOJET, 75°F, A= 1

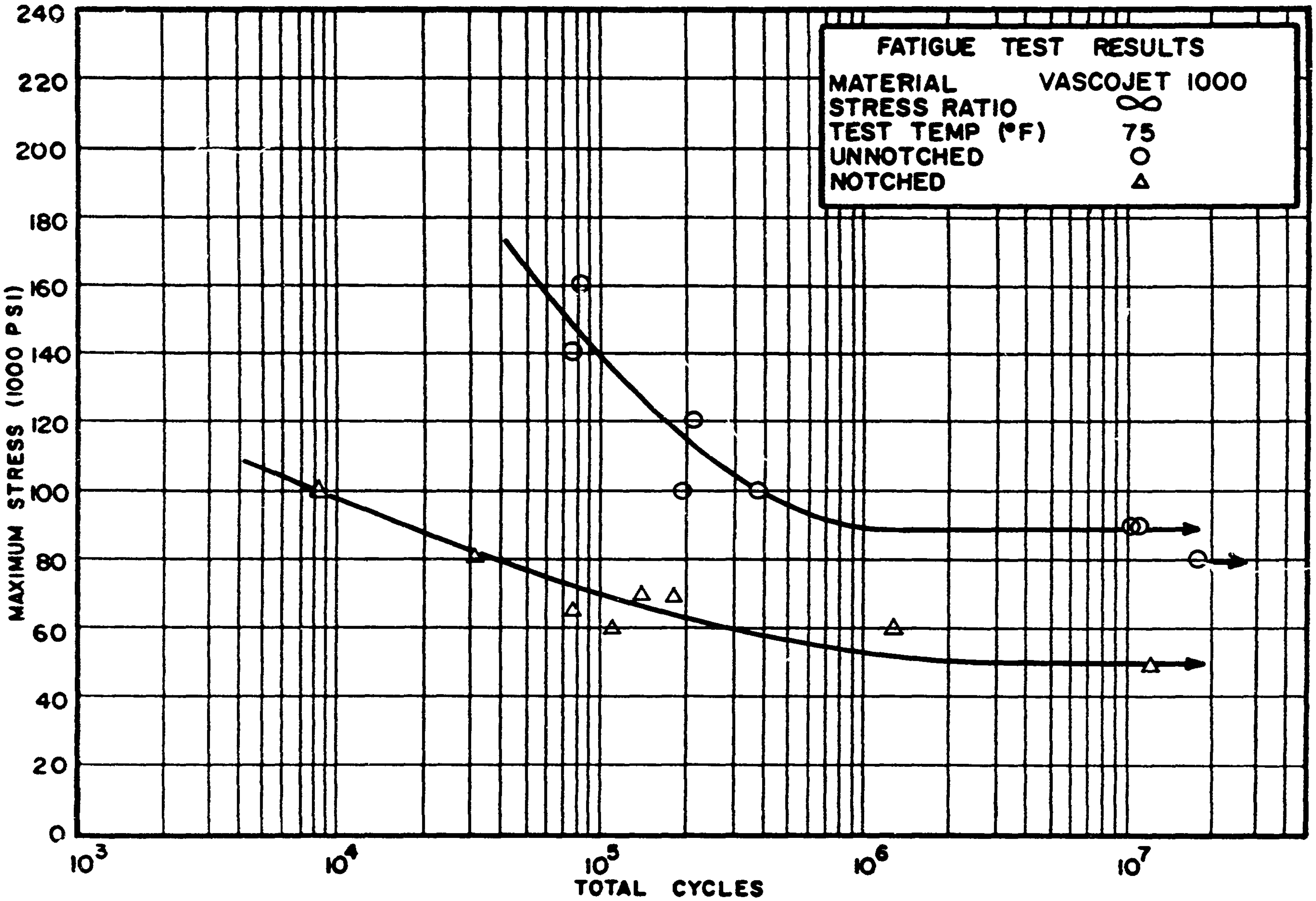


FIGURE 40 S-N DIAGRAMS : VASCOJET, 75°F, A = ∞

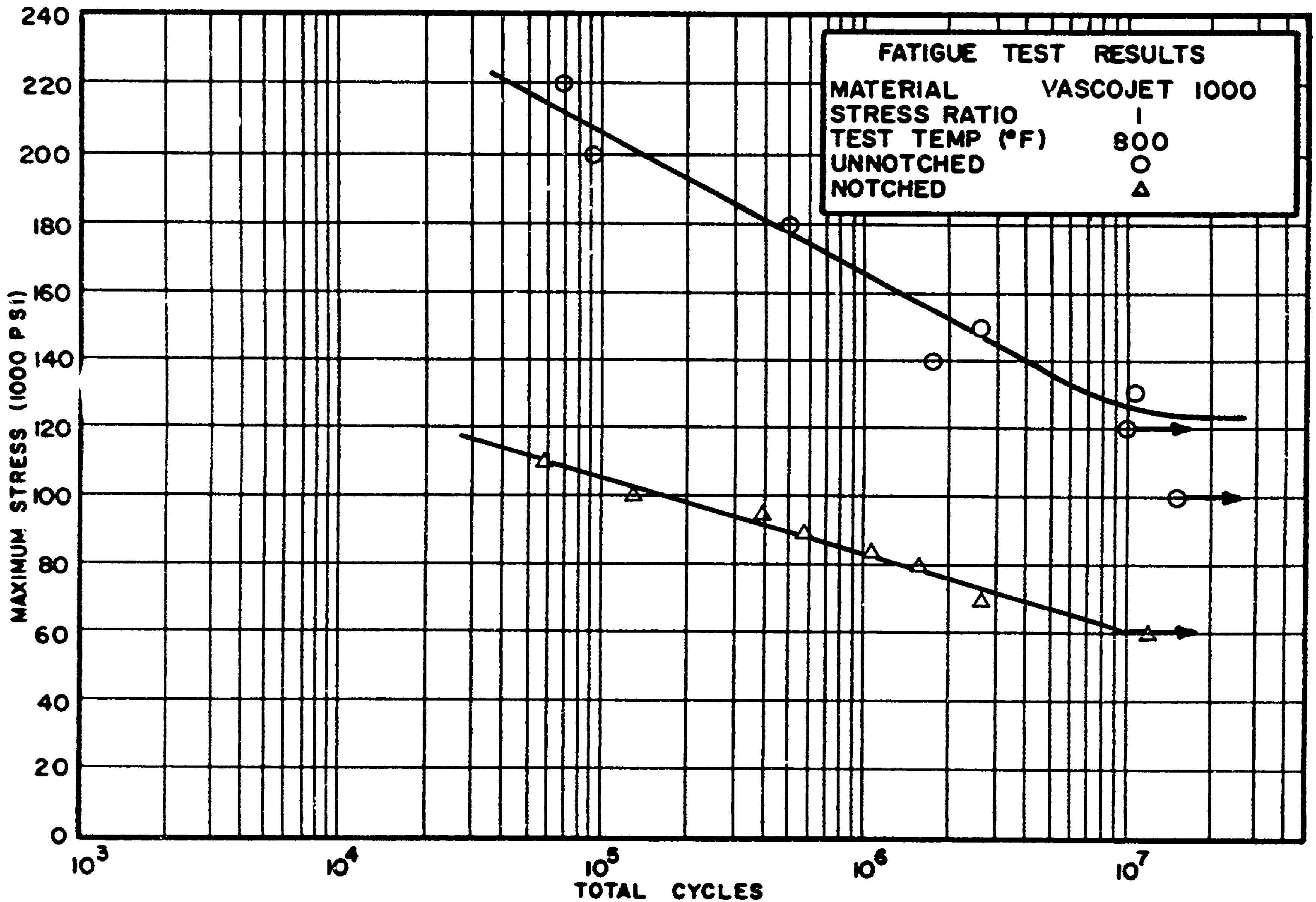


FIGURE 41 S-N DIAGRAMS : VASCOJET, 800°F, A= 1

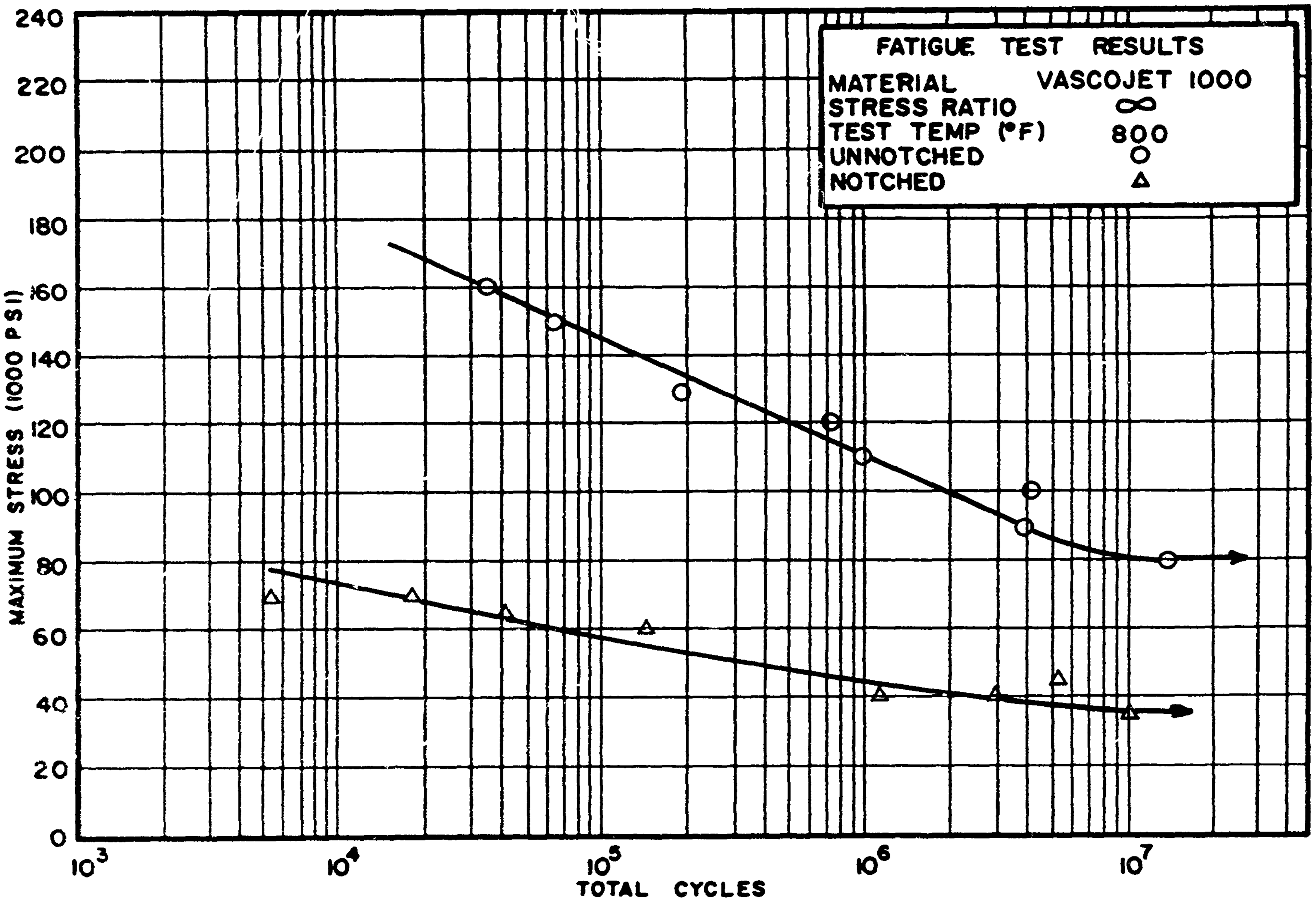


FIGURE 42 S-N DIAGRAMS: VASCOJET, 800° F, A= ∞

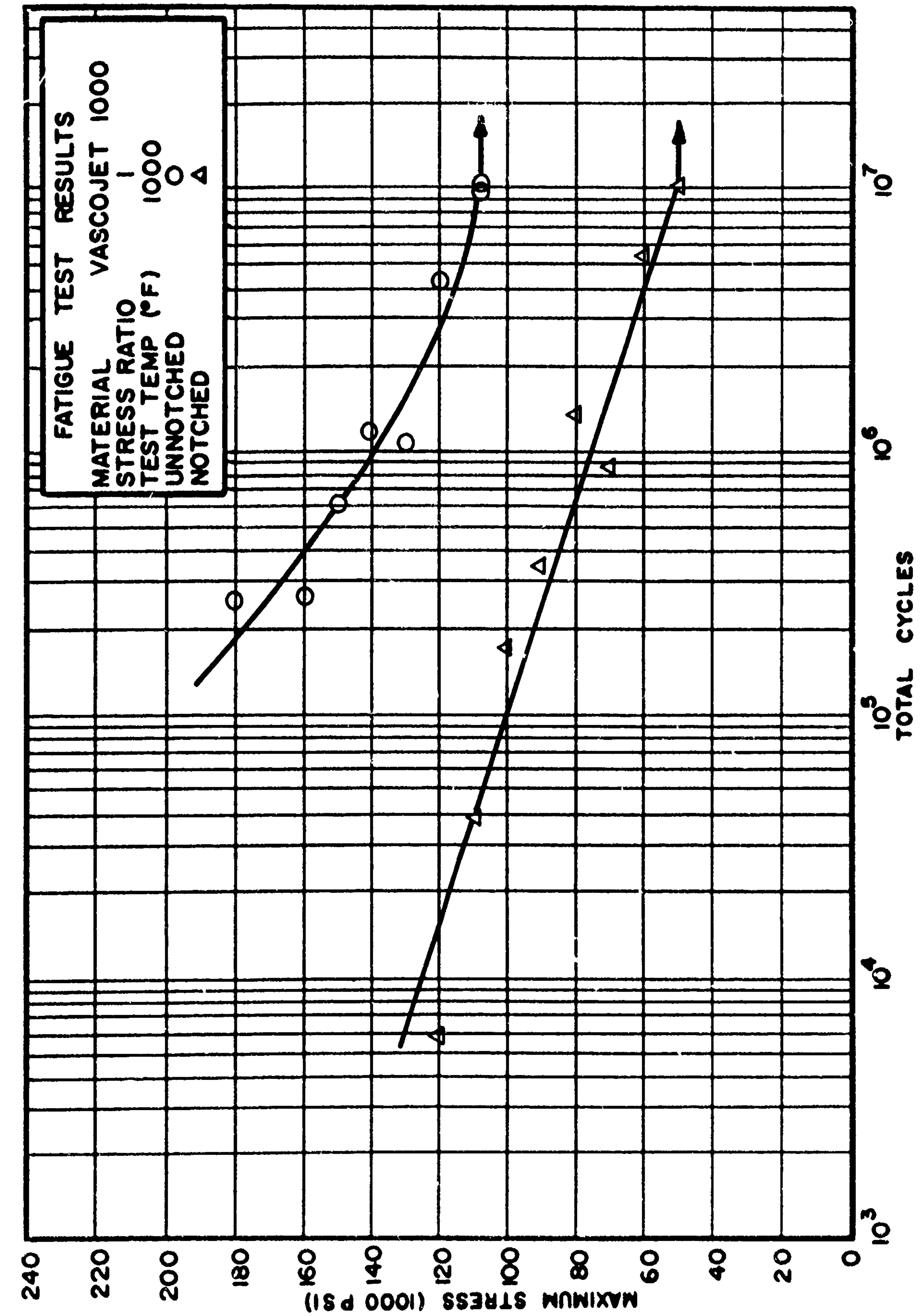


FIGURE 43 S-N DIAGRAMS: VASCOJET, 1000° F, A= 1

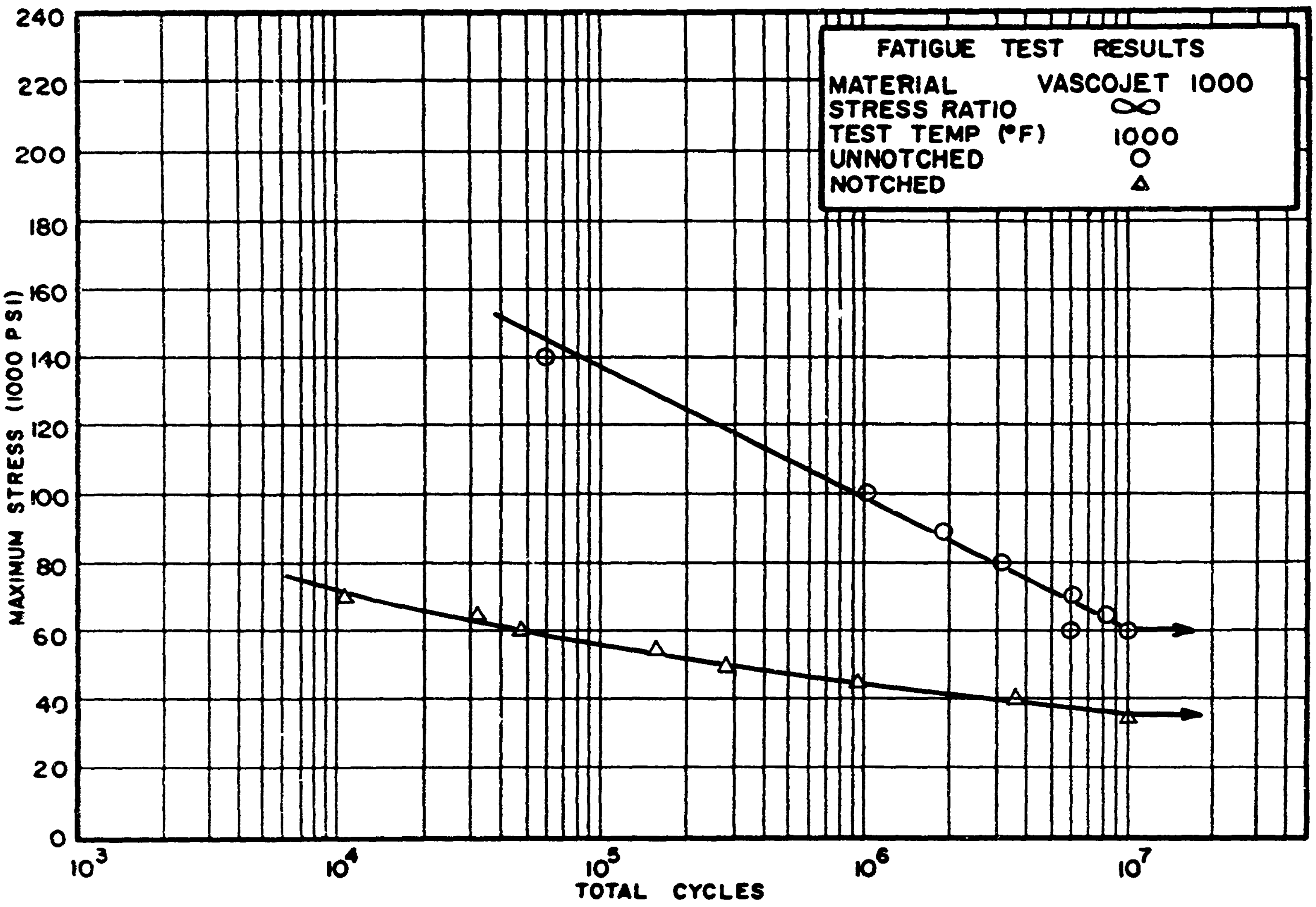


FIGURE 44 S-N DIAGRAMS: VASCOJET, 1000°F, A = ∞

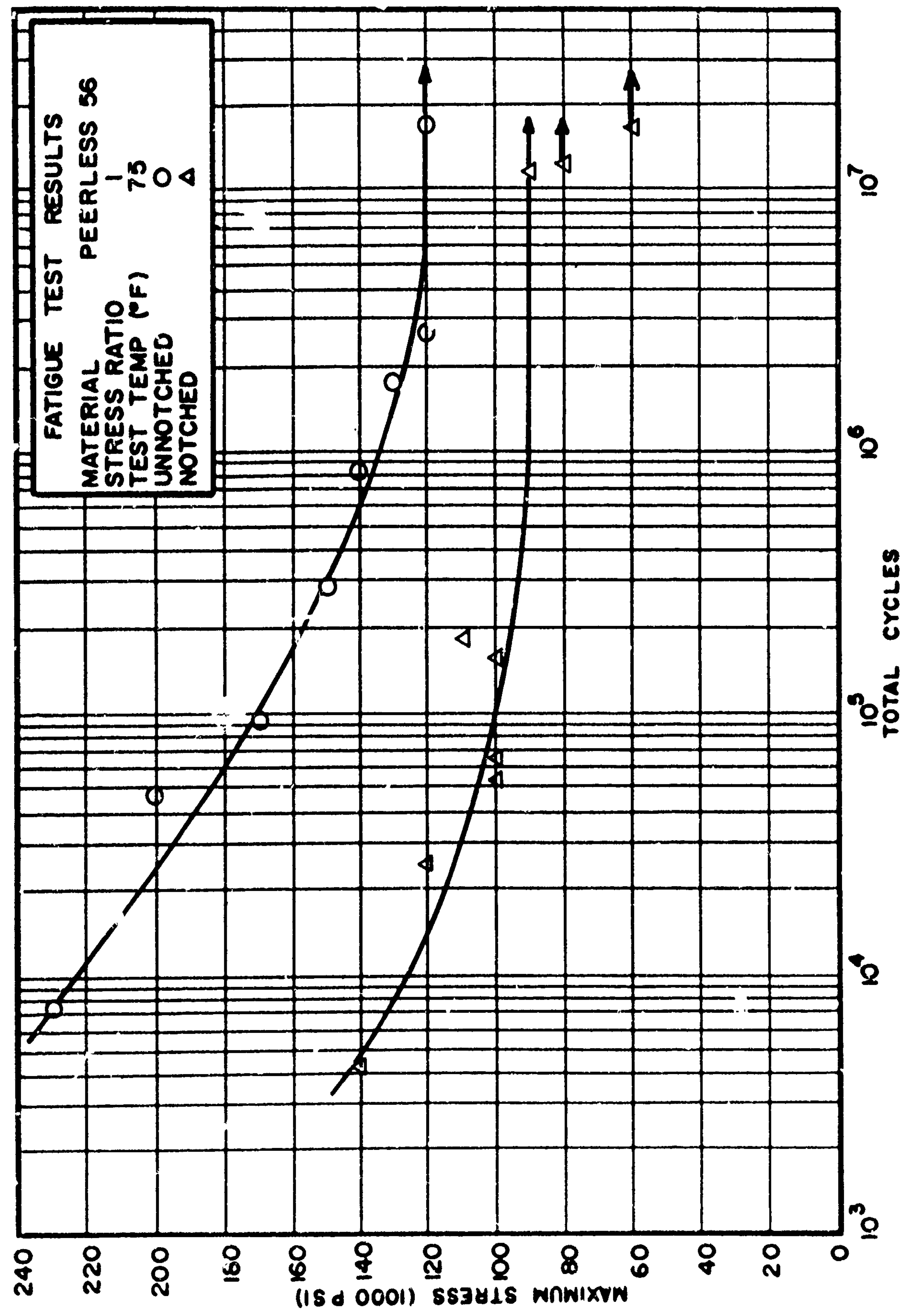


FIGURE 45 S-N DIAGRAMS : PEERLESS 56, 75°F, A= 1

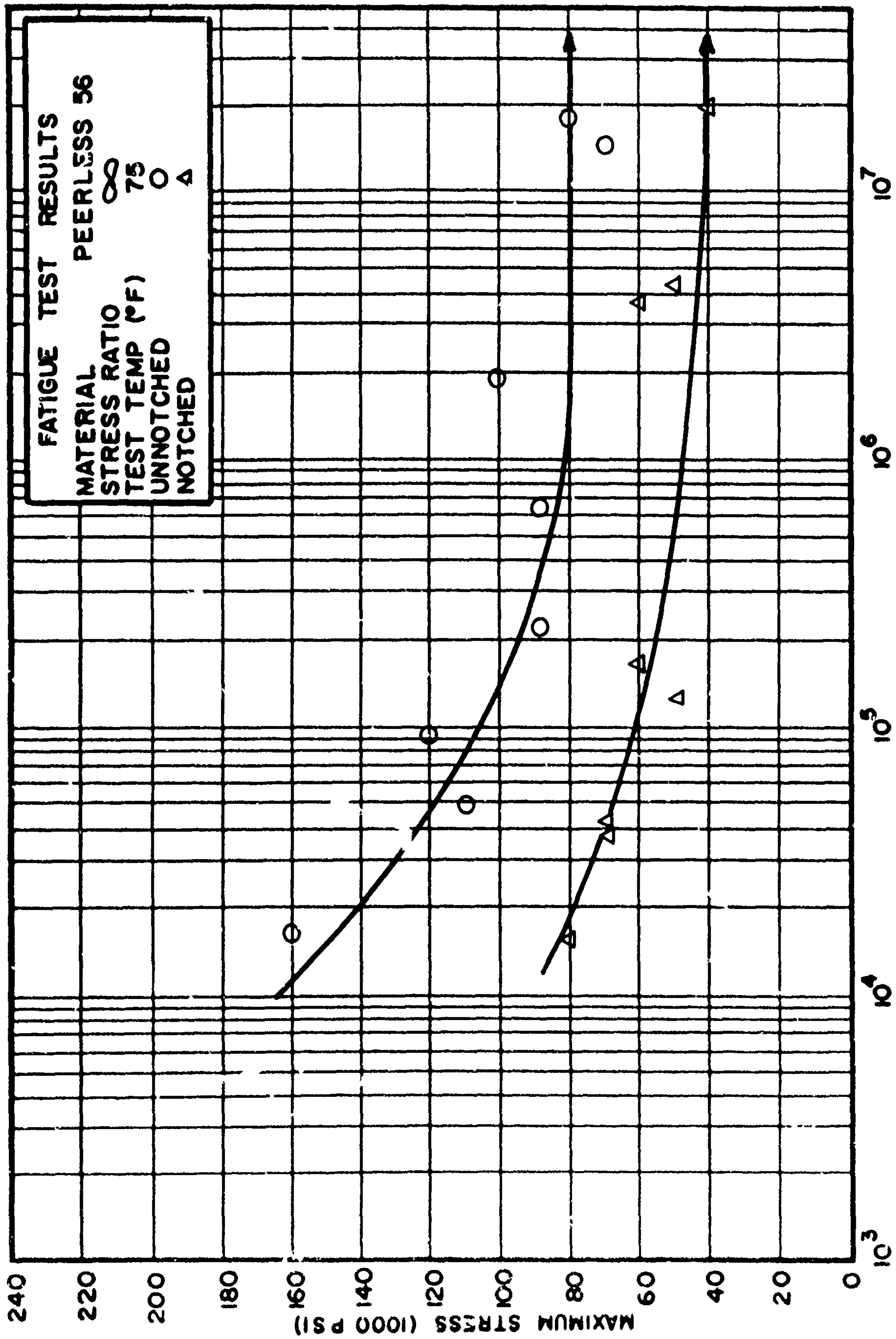


FIGURE 46 S-N DIAGRAMS: PEERLESS 56, 75°F, A= ∞

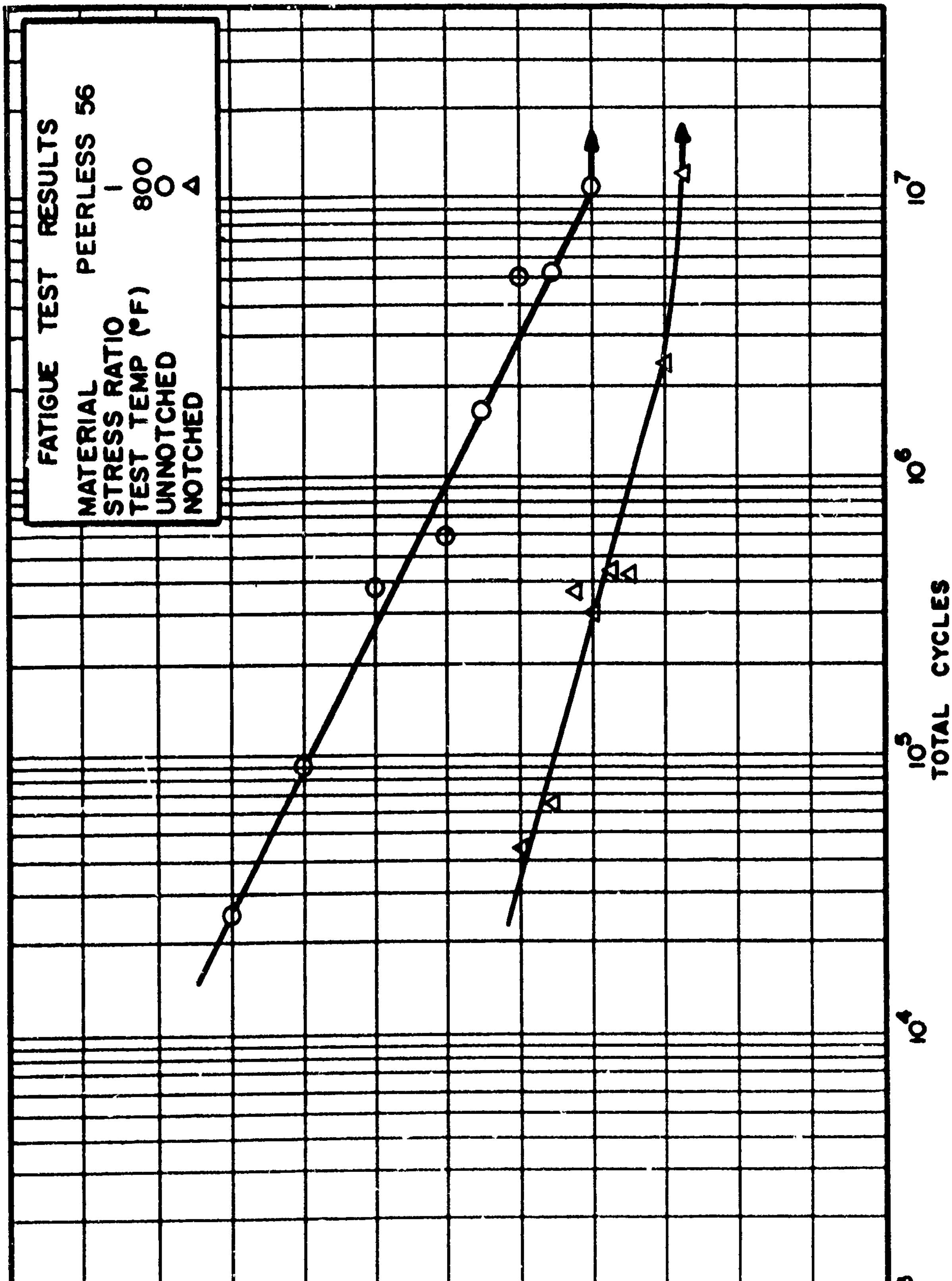


FIGURE 47 S-N DIAGRAMS: PEERLESS 56, 800°F, A = 1

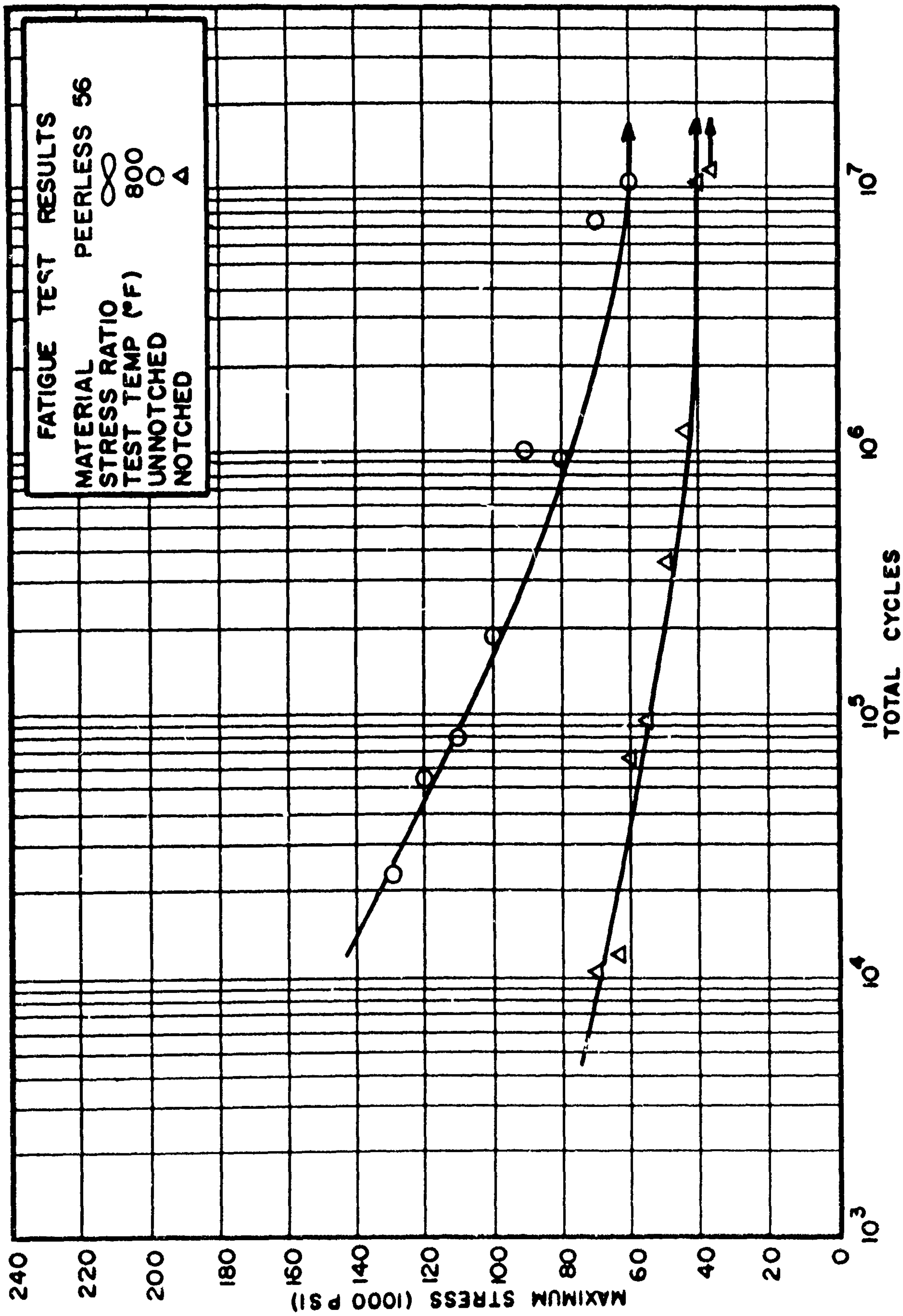


FIGURE 48 S-N DIAGRAMS: PEERLESS 56, 800°F, A= ∞

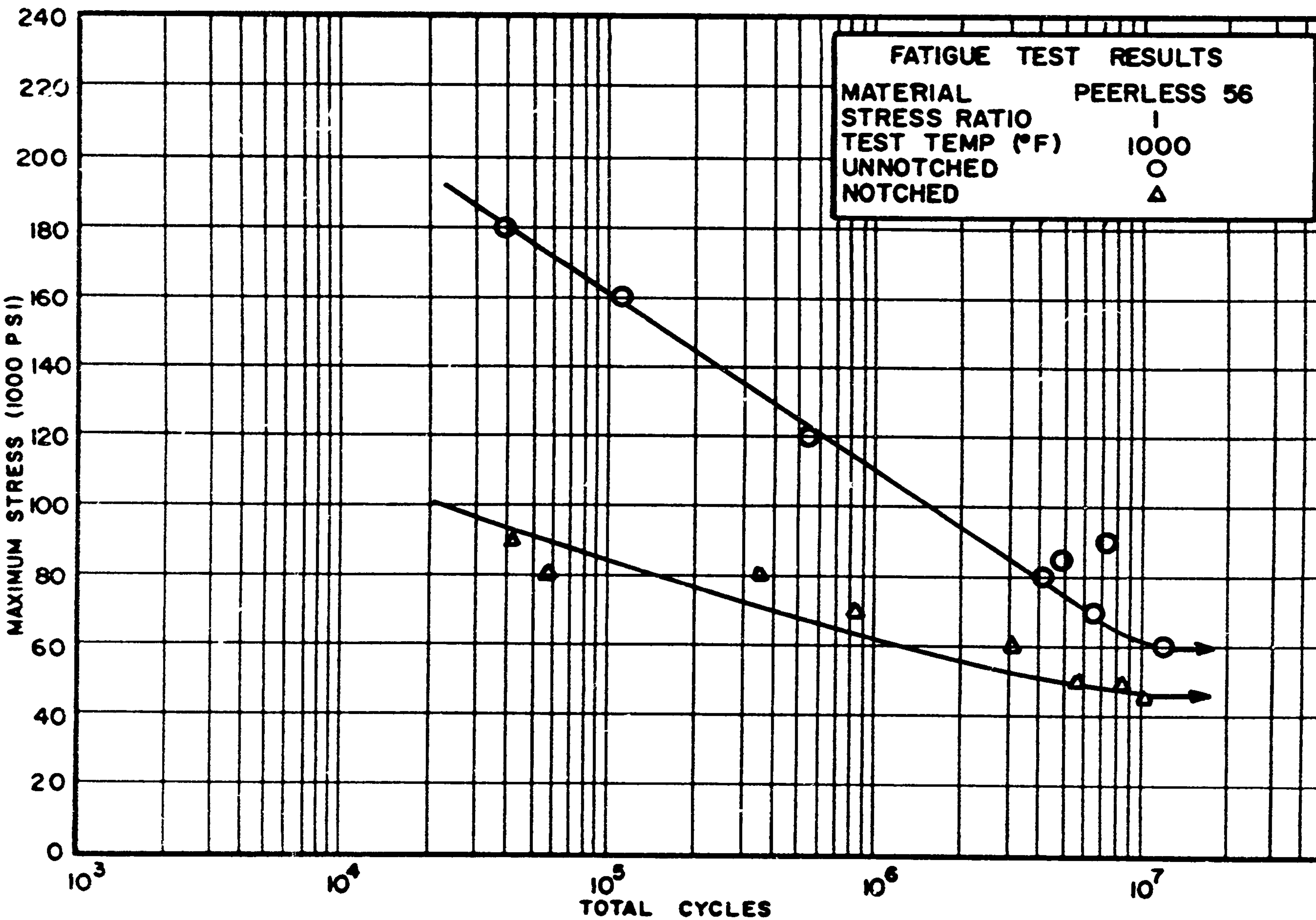


FIGURE 49 S-N DIAGRAMS: PEERLESS 56, 1000°F, A= 1

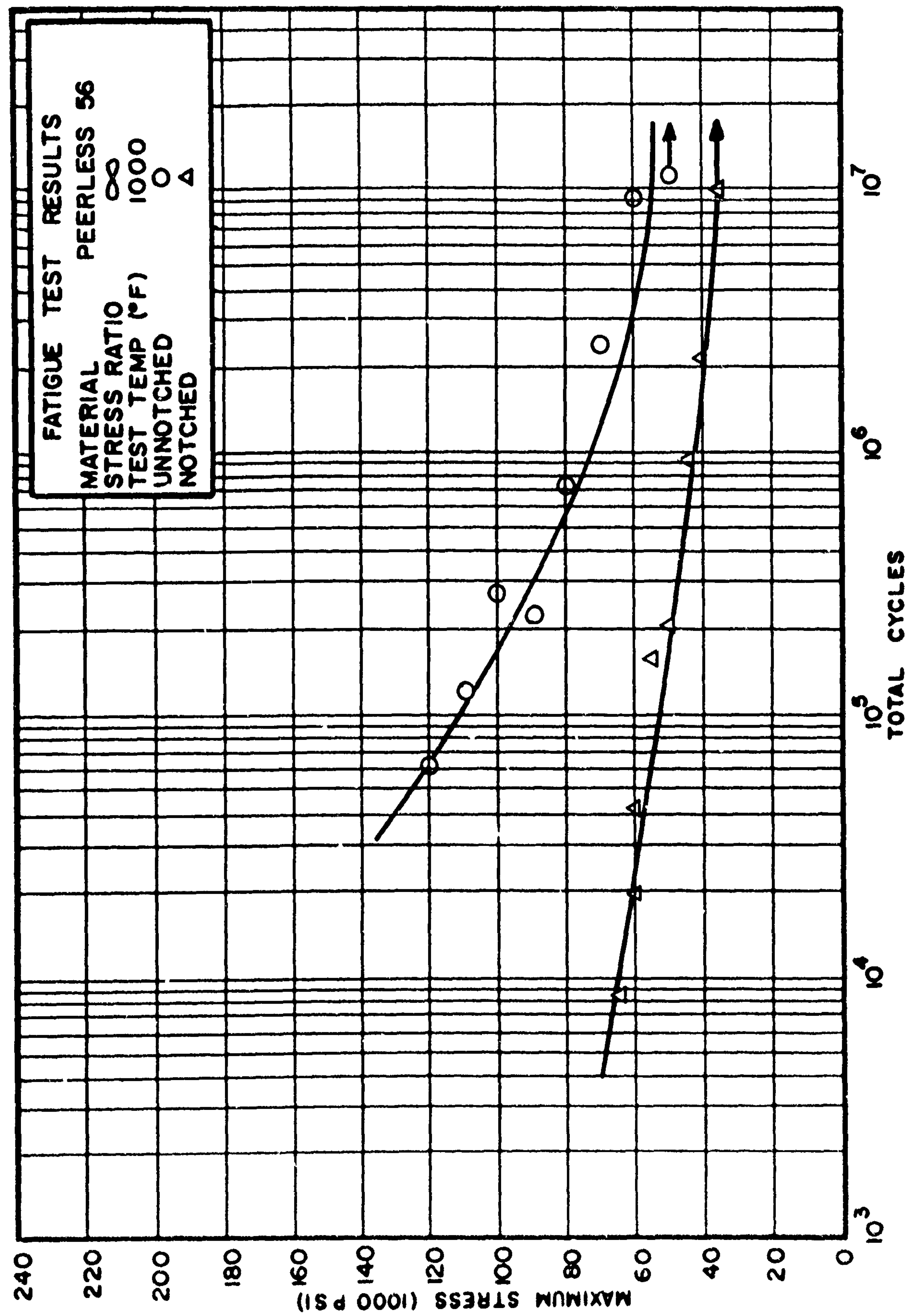
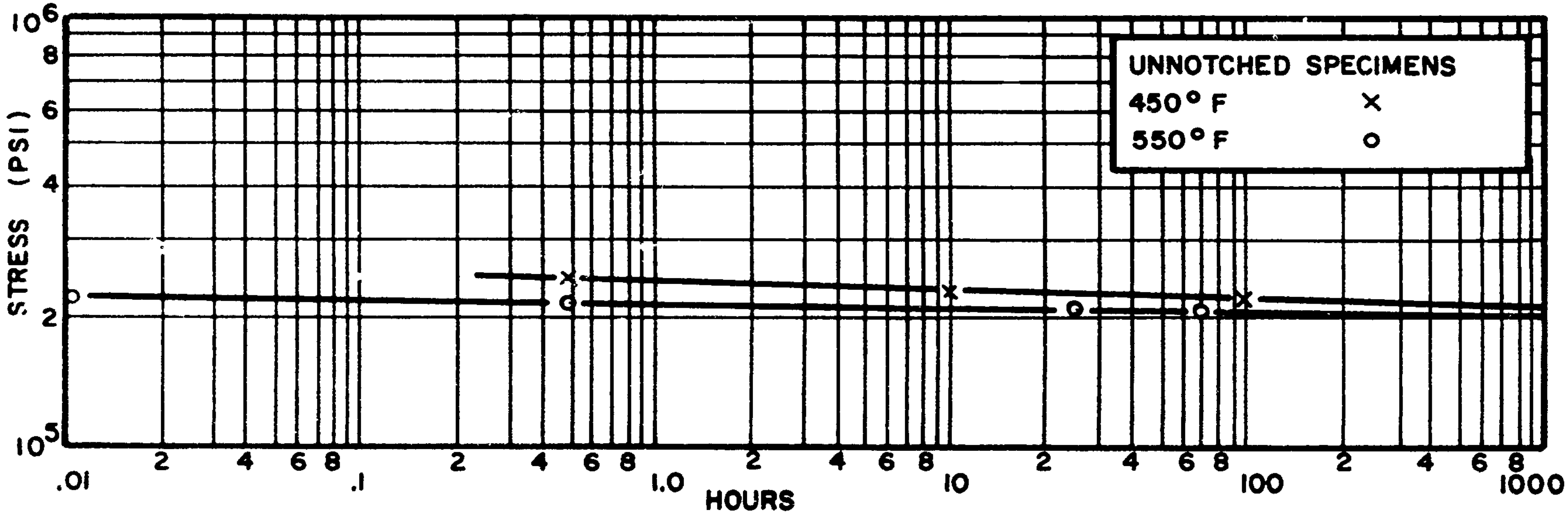


FIGURE 50 S-N DIAGRAMS: PEERLESS 56, 1000°F, A = ∞



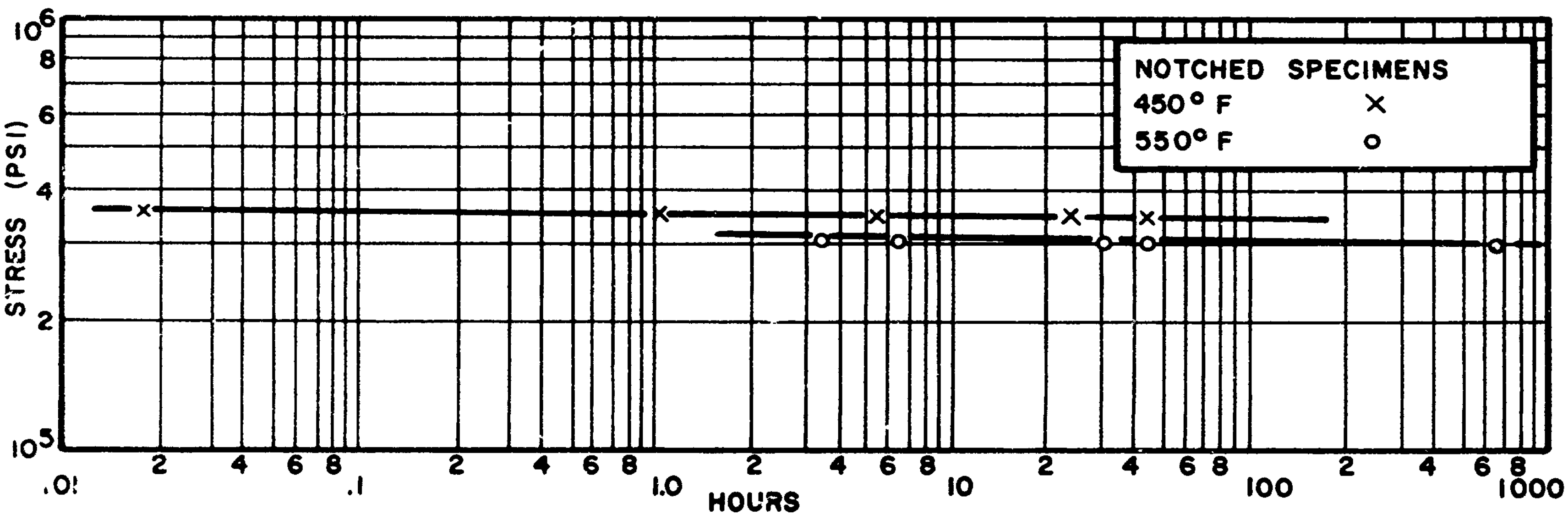


FIGURE 51 STRESS RUPTURE DATA: D6AC

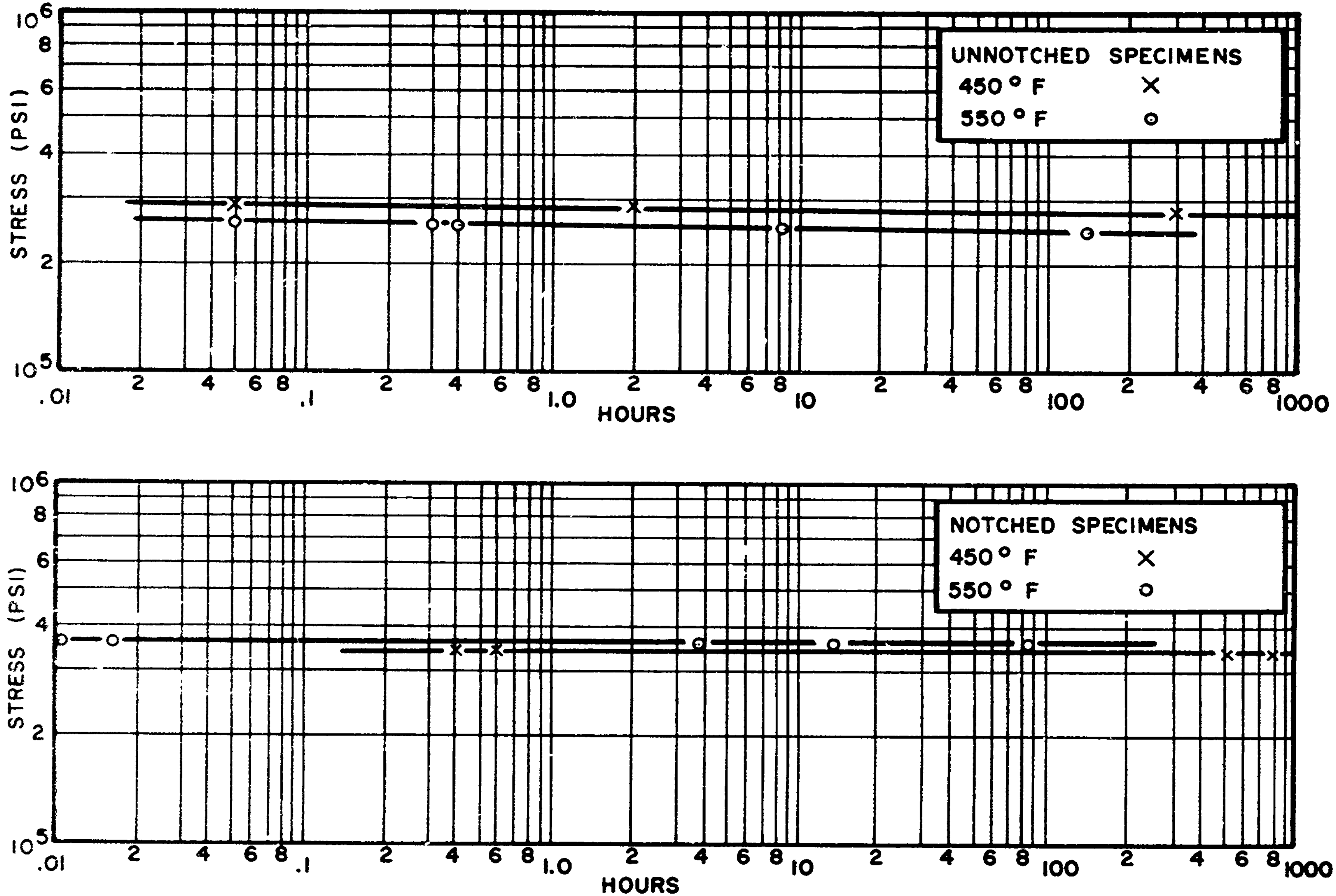


FIGURE 52 STRESS RUPTURE DATA: LABELLE HT

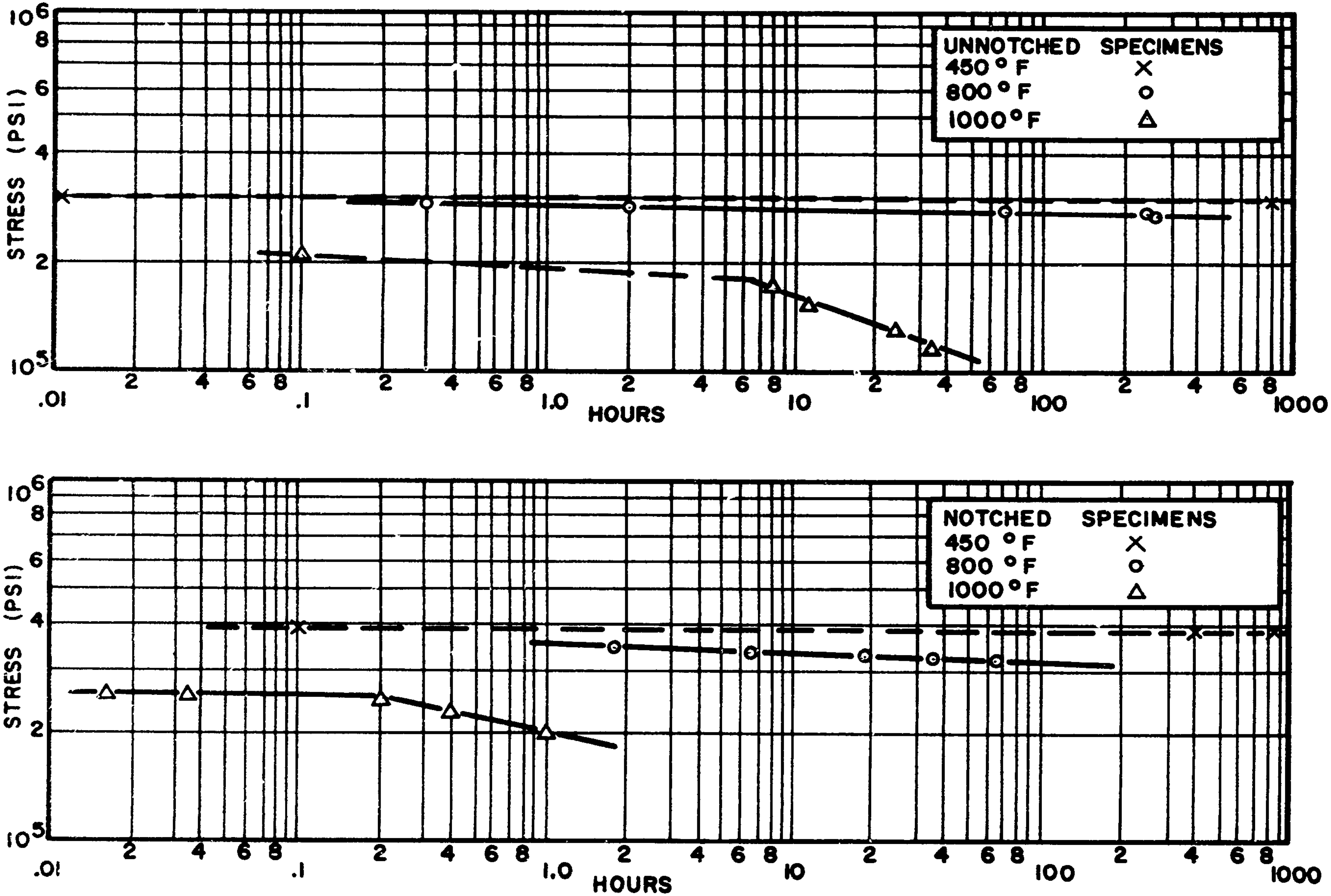
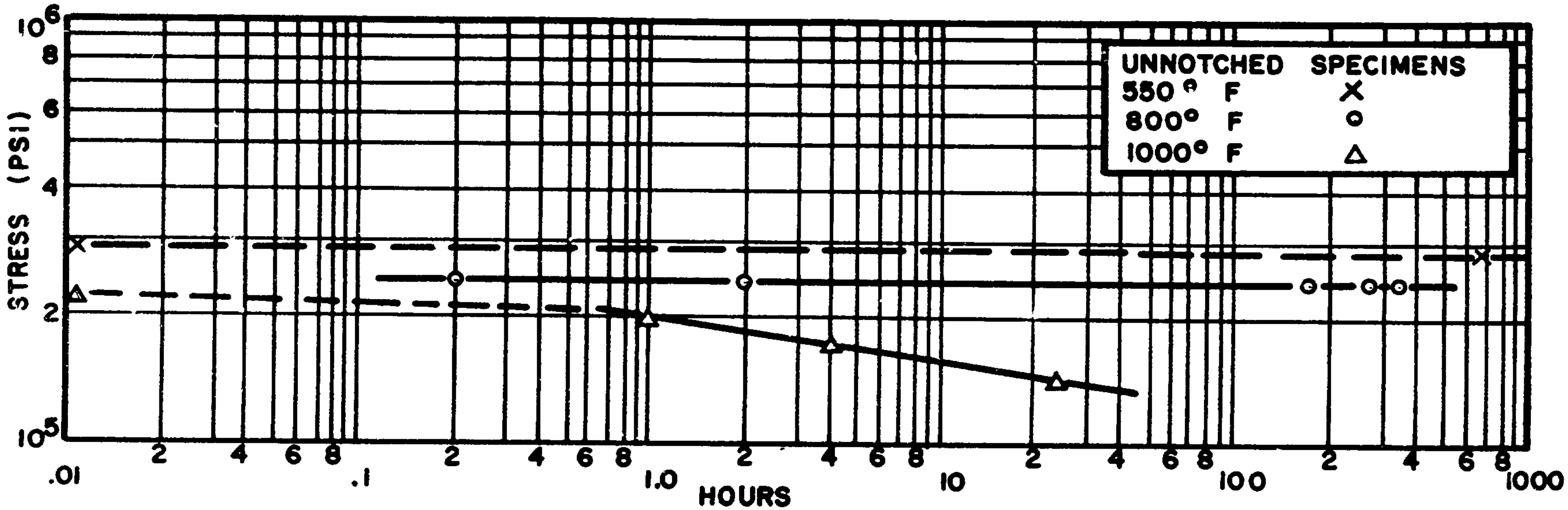


FIGURE 53 STRESS RUPTURE DATA: THERMOLD J



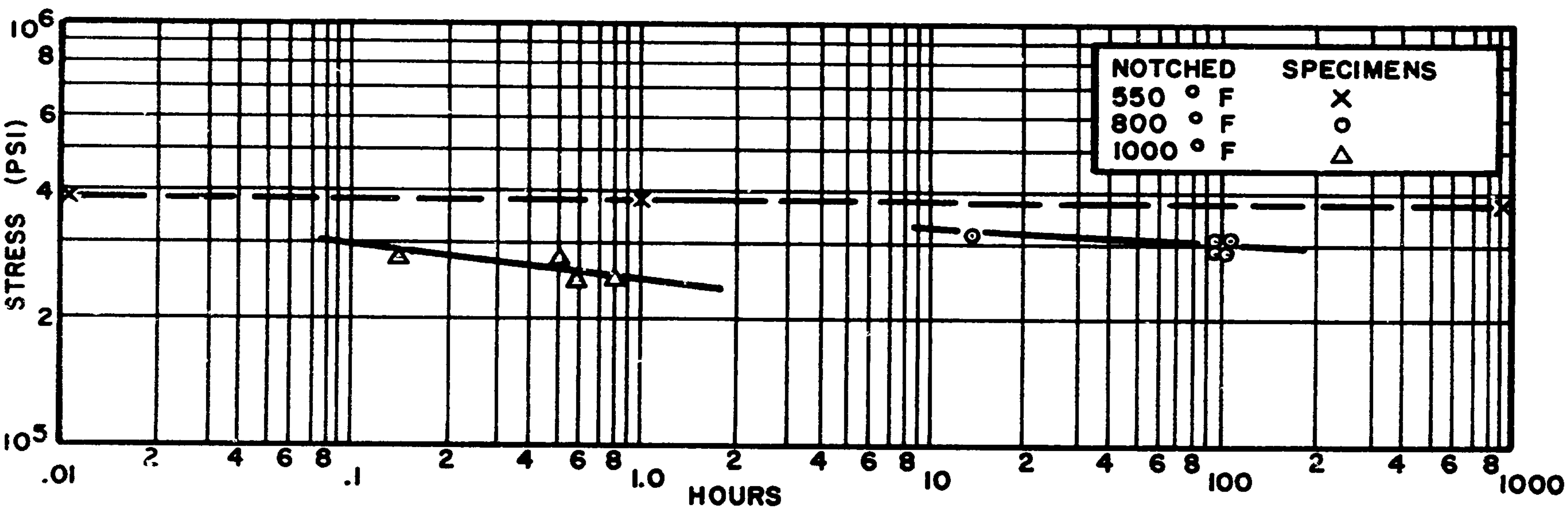


FIGURE 54 STRESS RUPTURE DATA: VASCOJET

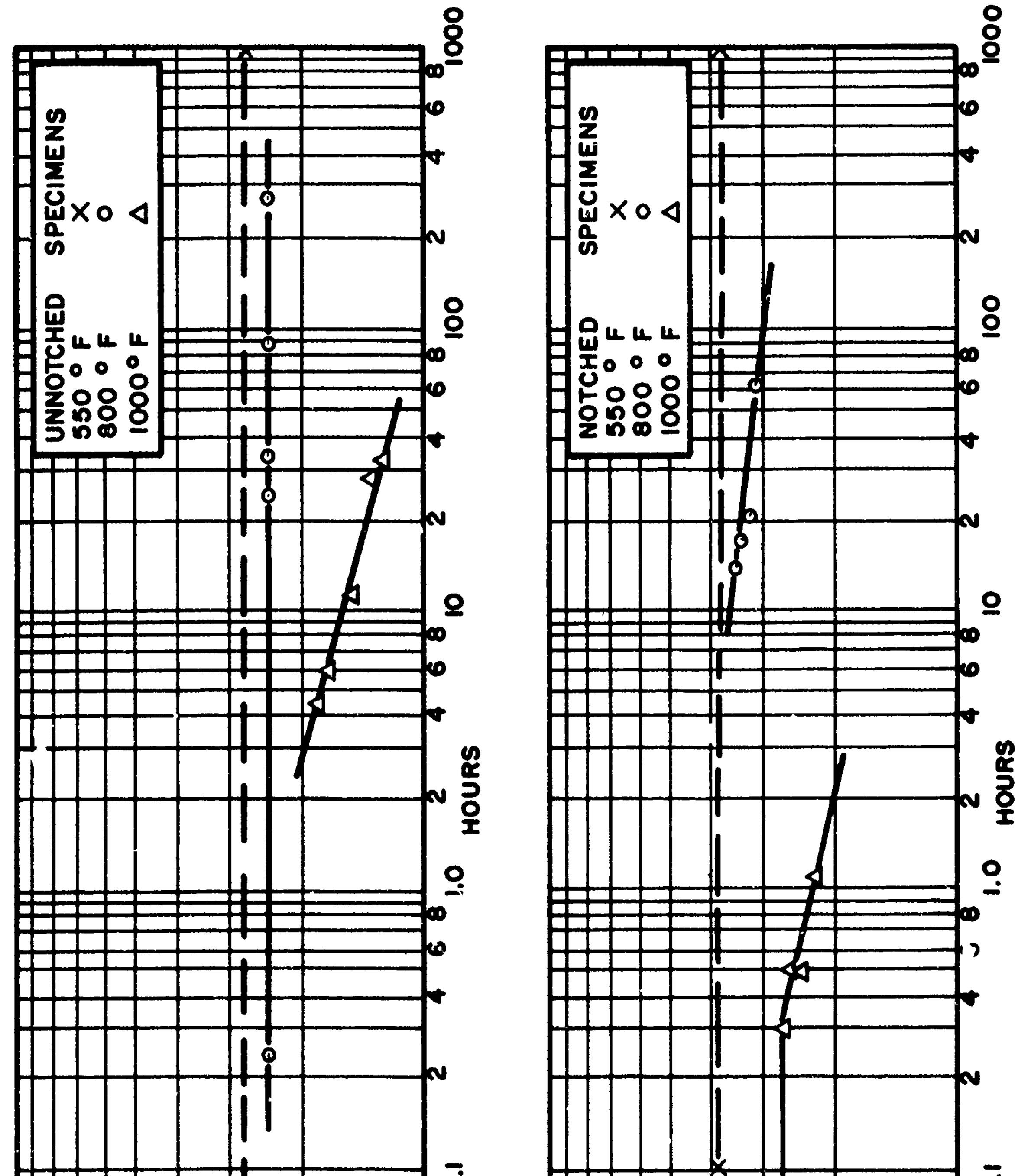


FIGURE 55 STRESS RUPTURE DATA: PEERLESS 56

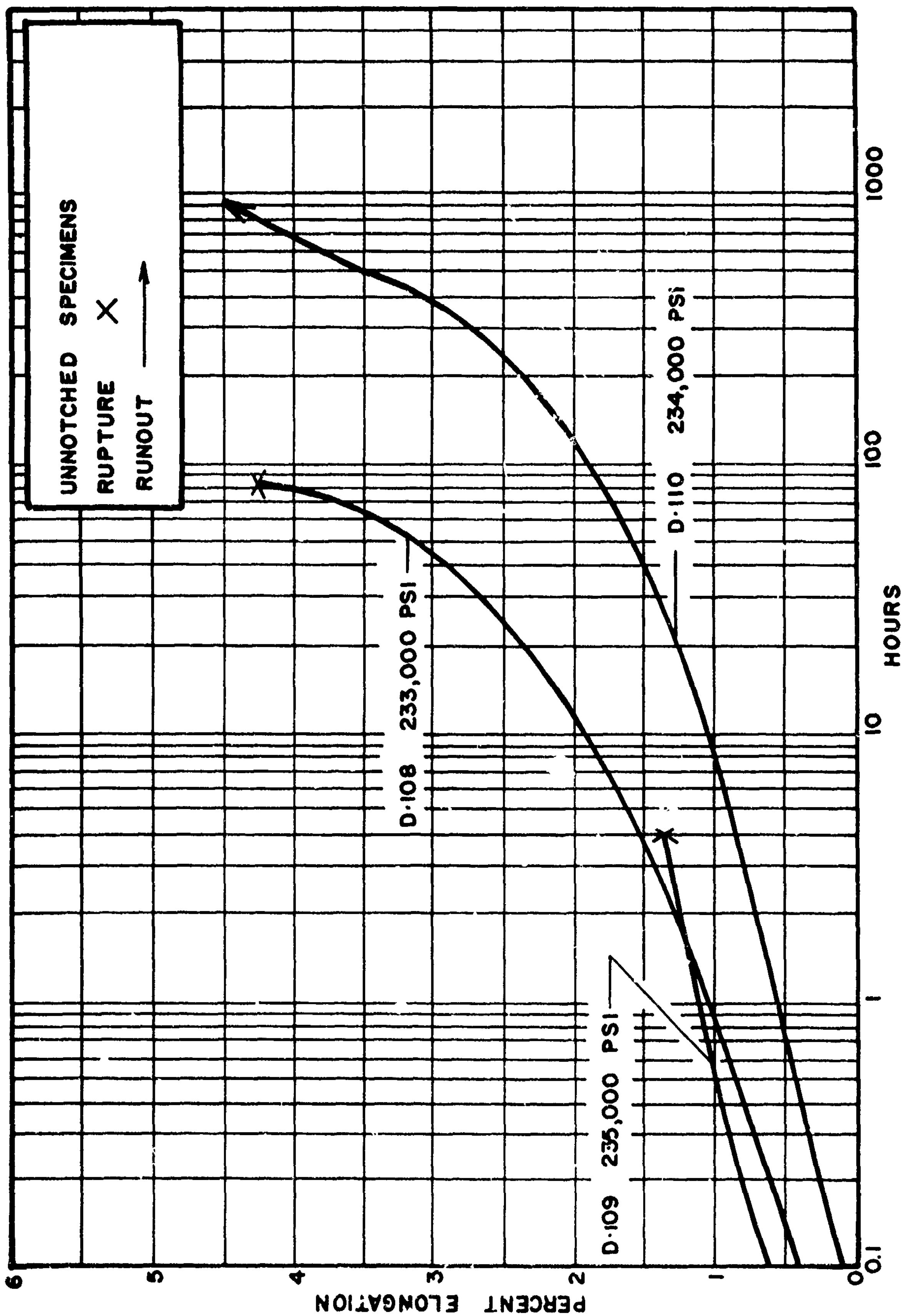


FIGURE 56 STATIC CREEP: D6AC, 450° F

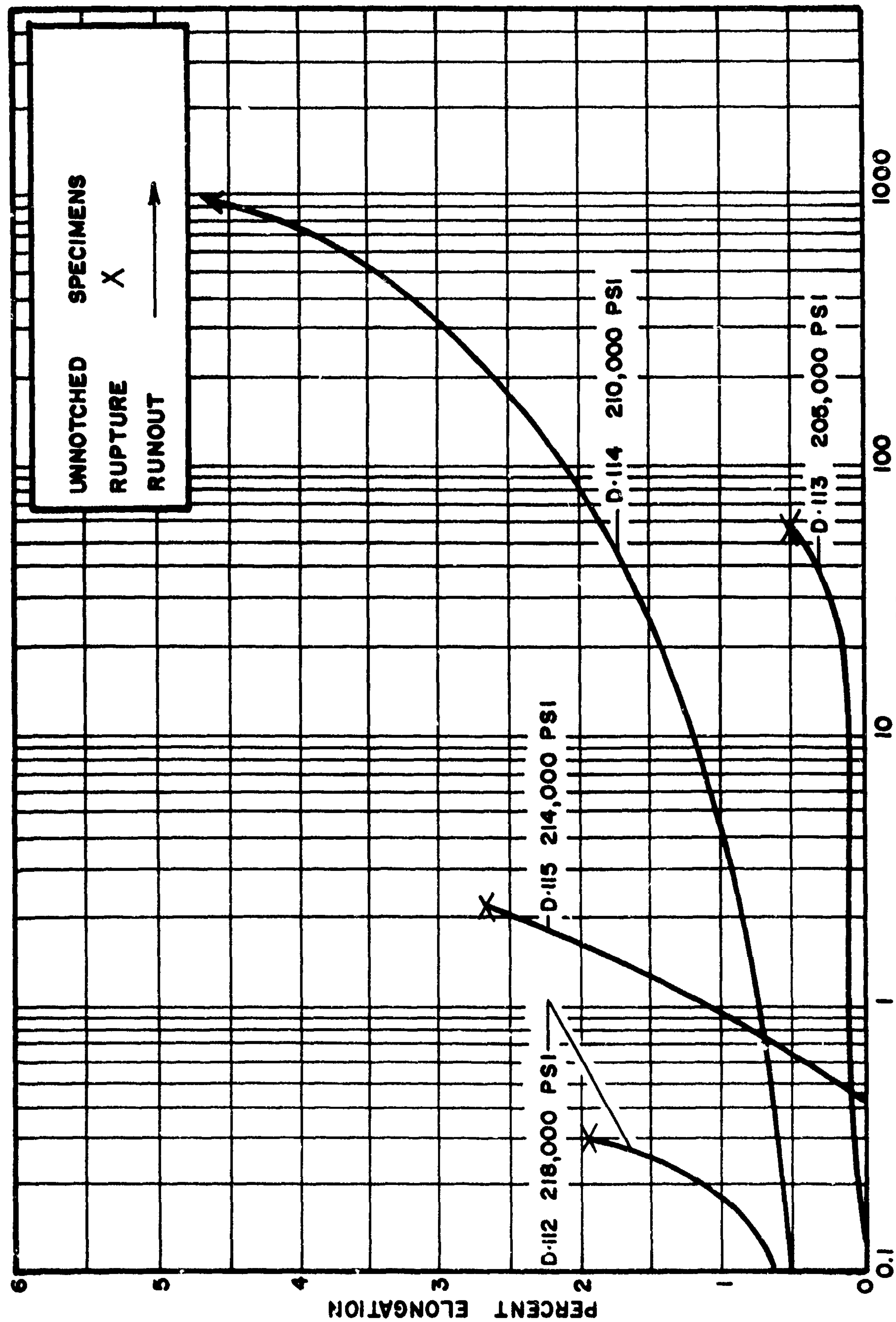


FIGURE 57 STATIC CREEP: D6AC, 550° F

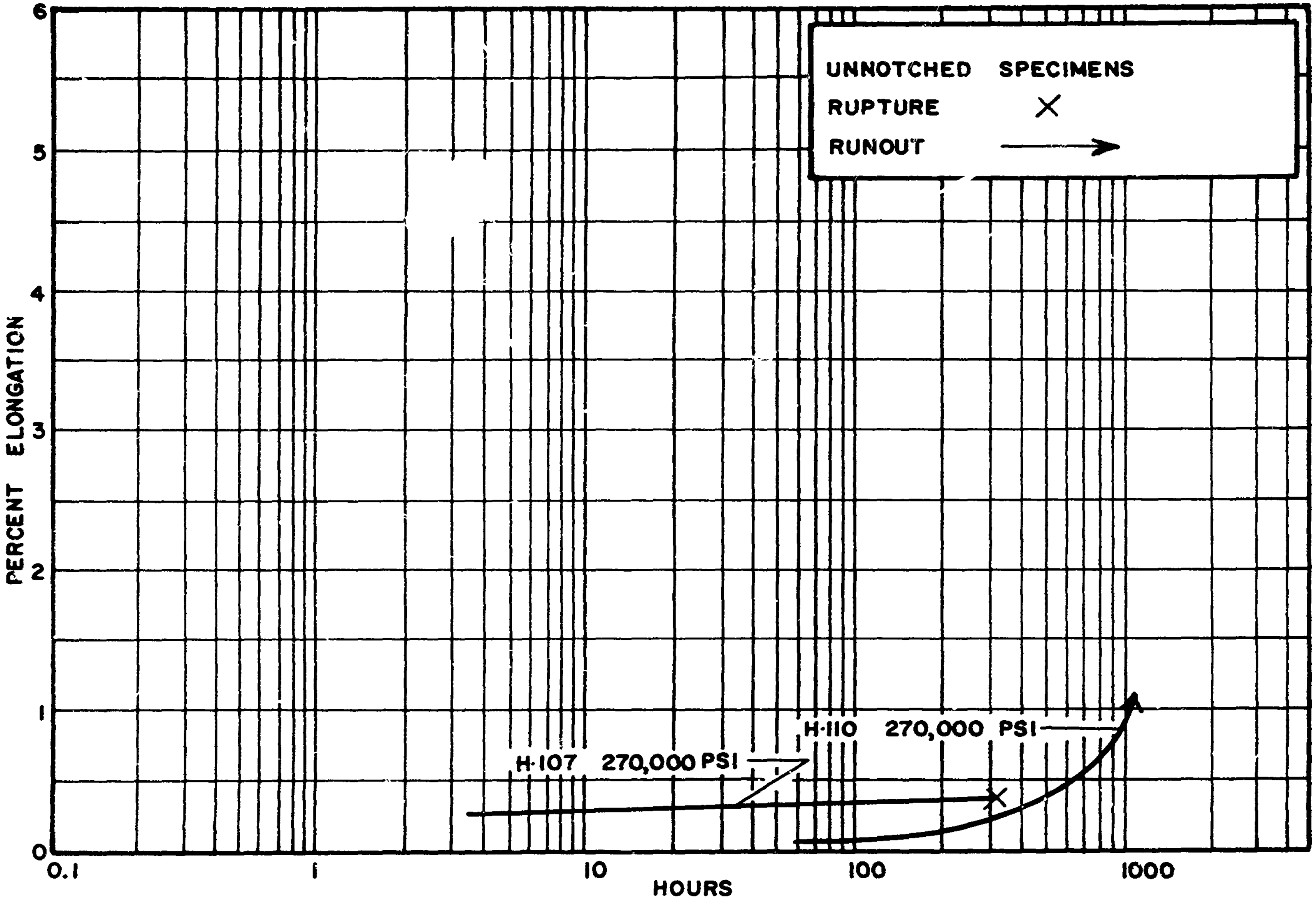


FIGURE 58 STATIC CREEP: LABELLE HT, 450°F

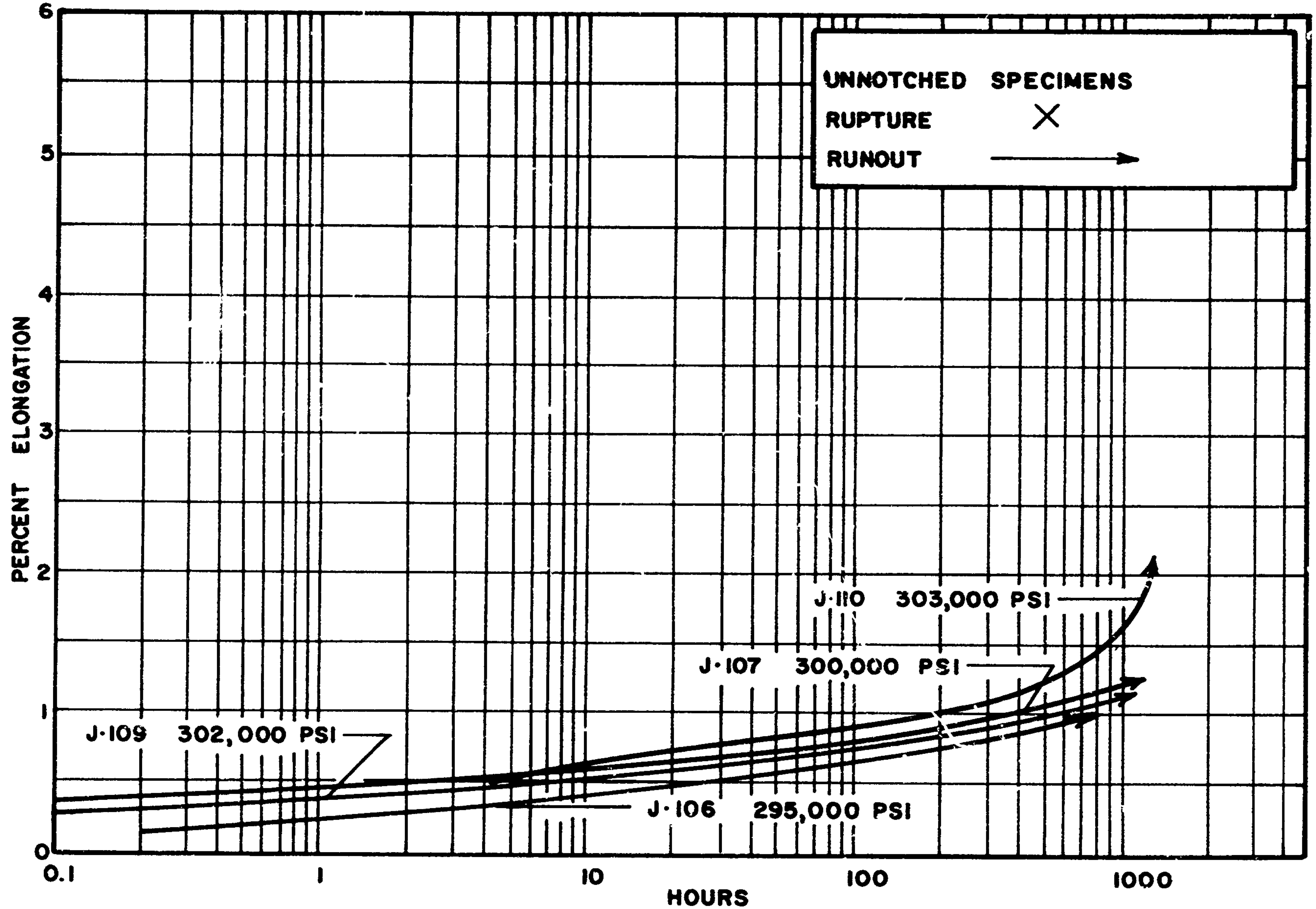


FIGURE 59 STATIC CREEP: THERMOLD J, 450° F

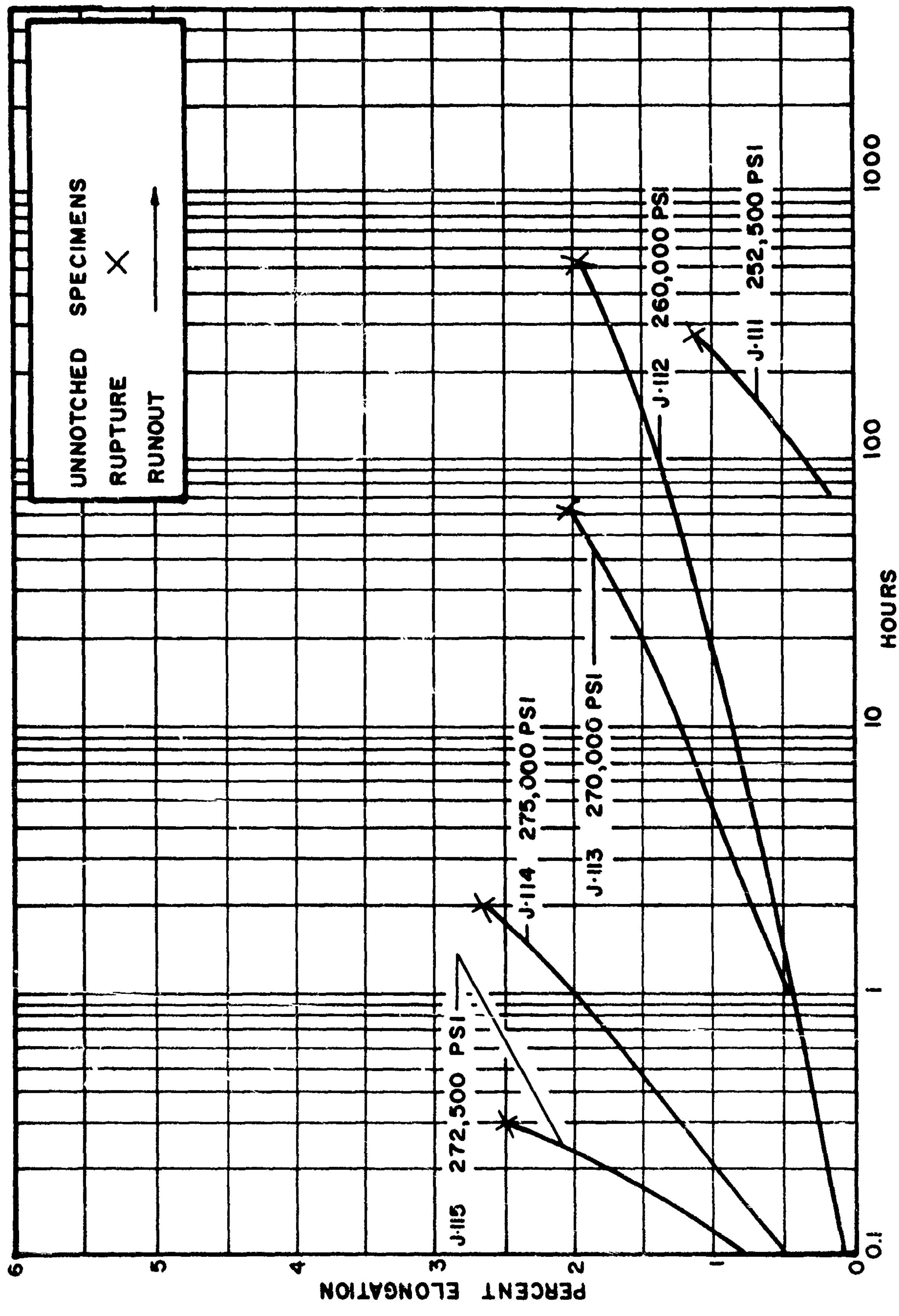


FIGURE 60 STATIC CREEP: THERMOLD J, 800°F

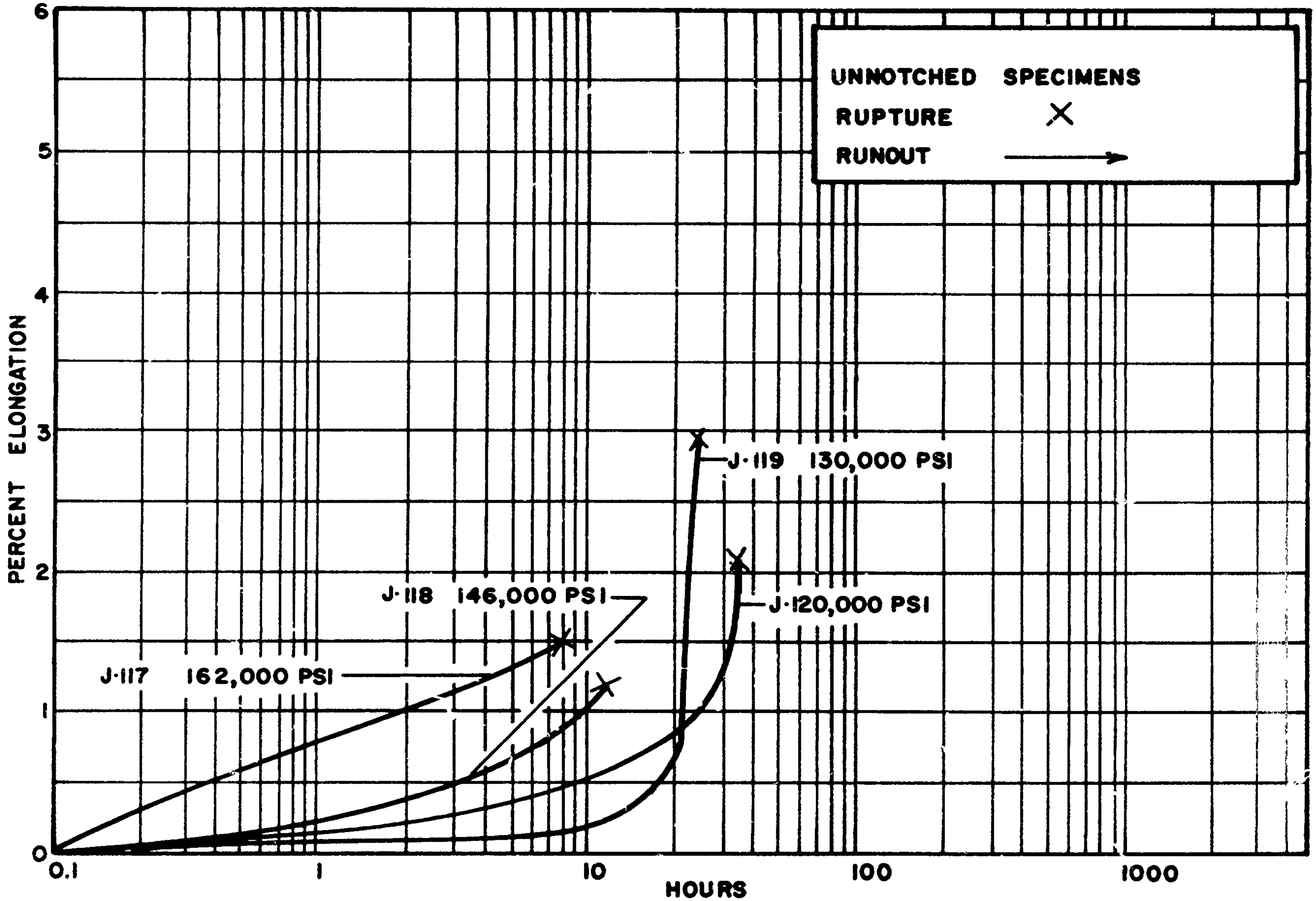


FIGURE 61 STATIC CREEP: THERMOLD J, 1000°F

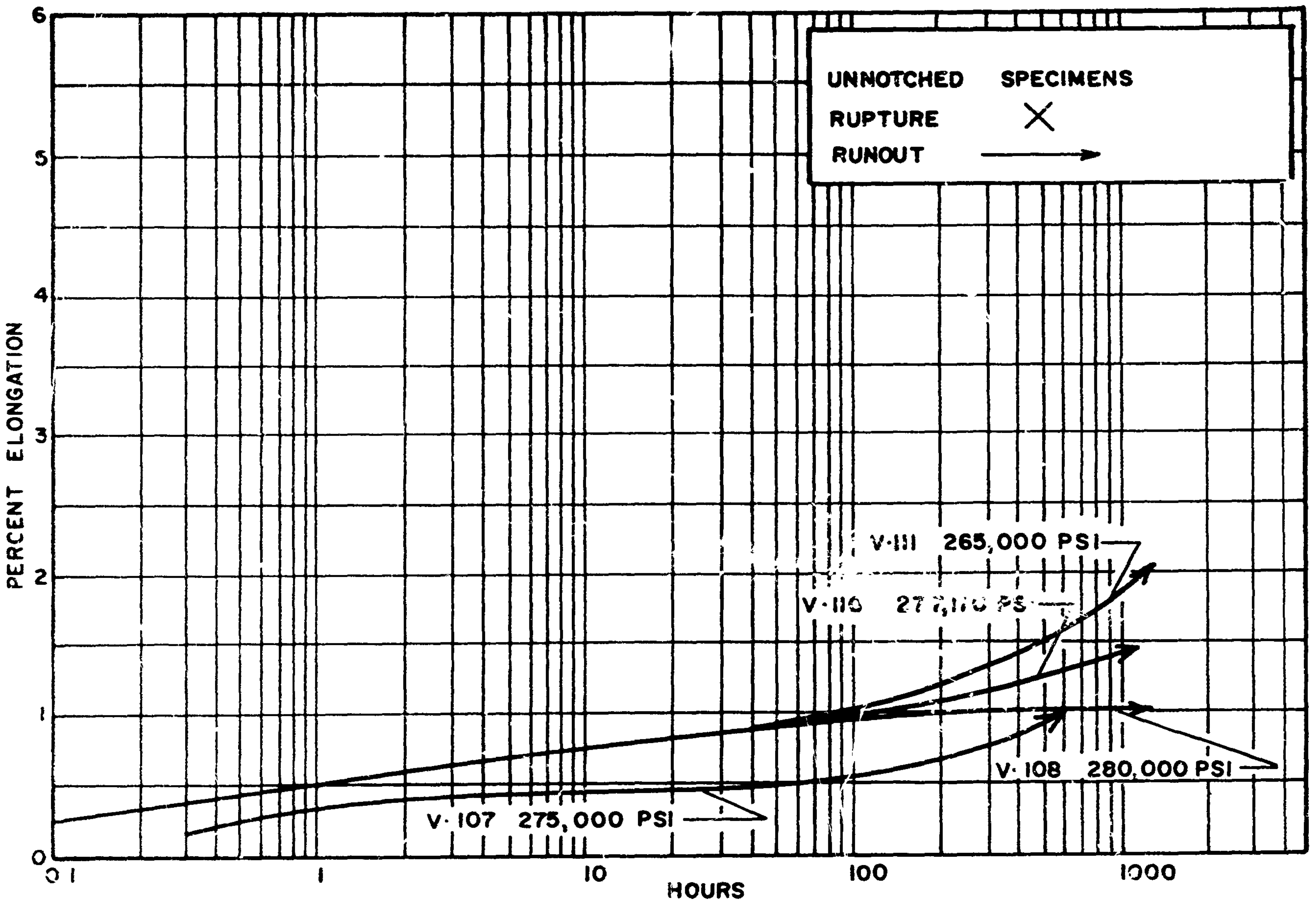


FIGURE 62 STATIC CREEP: VASCOJET, 550°F

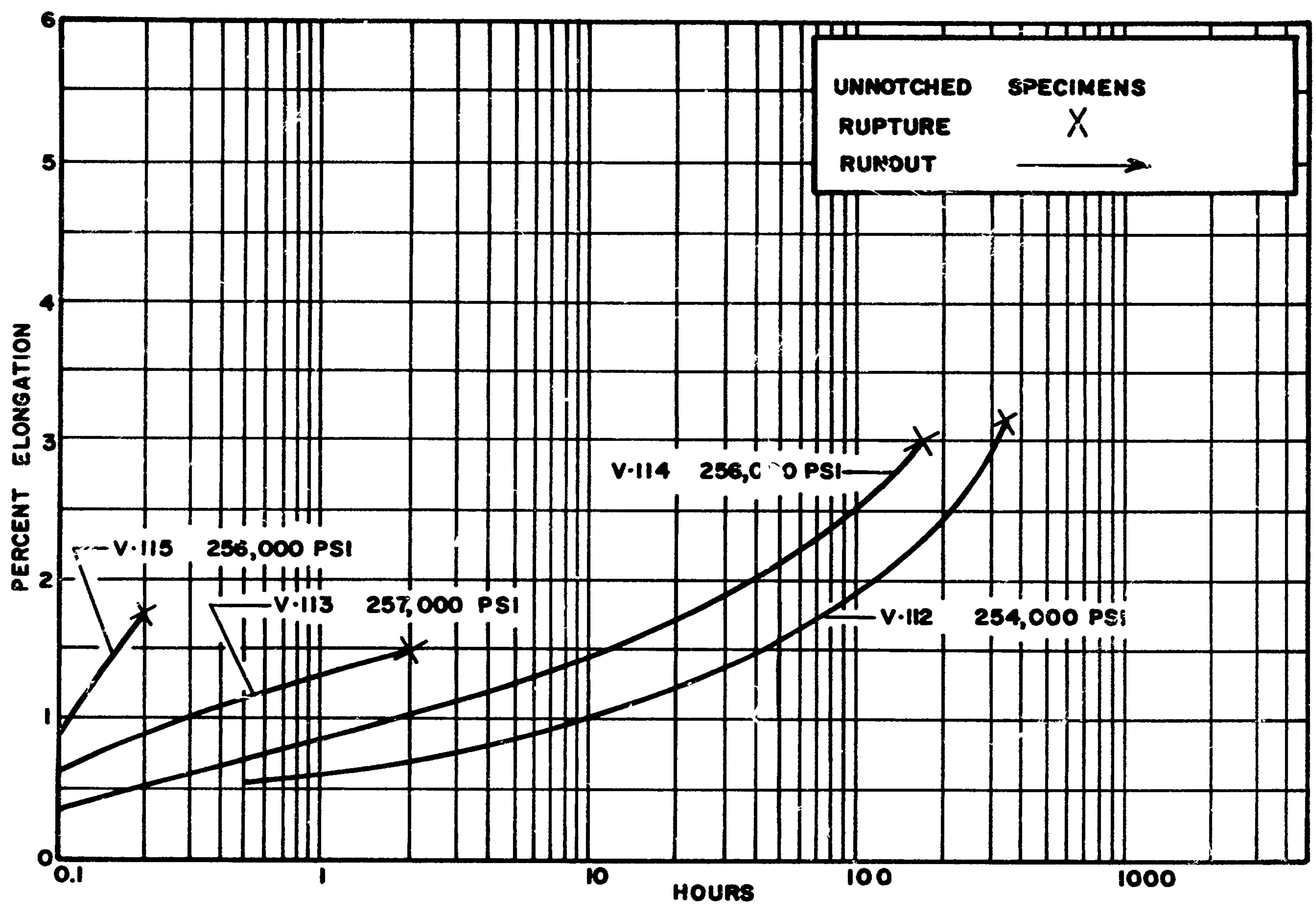


FIGURE 63 STATIC CREEP: VASCOJET, 800° F

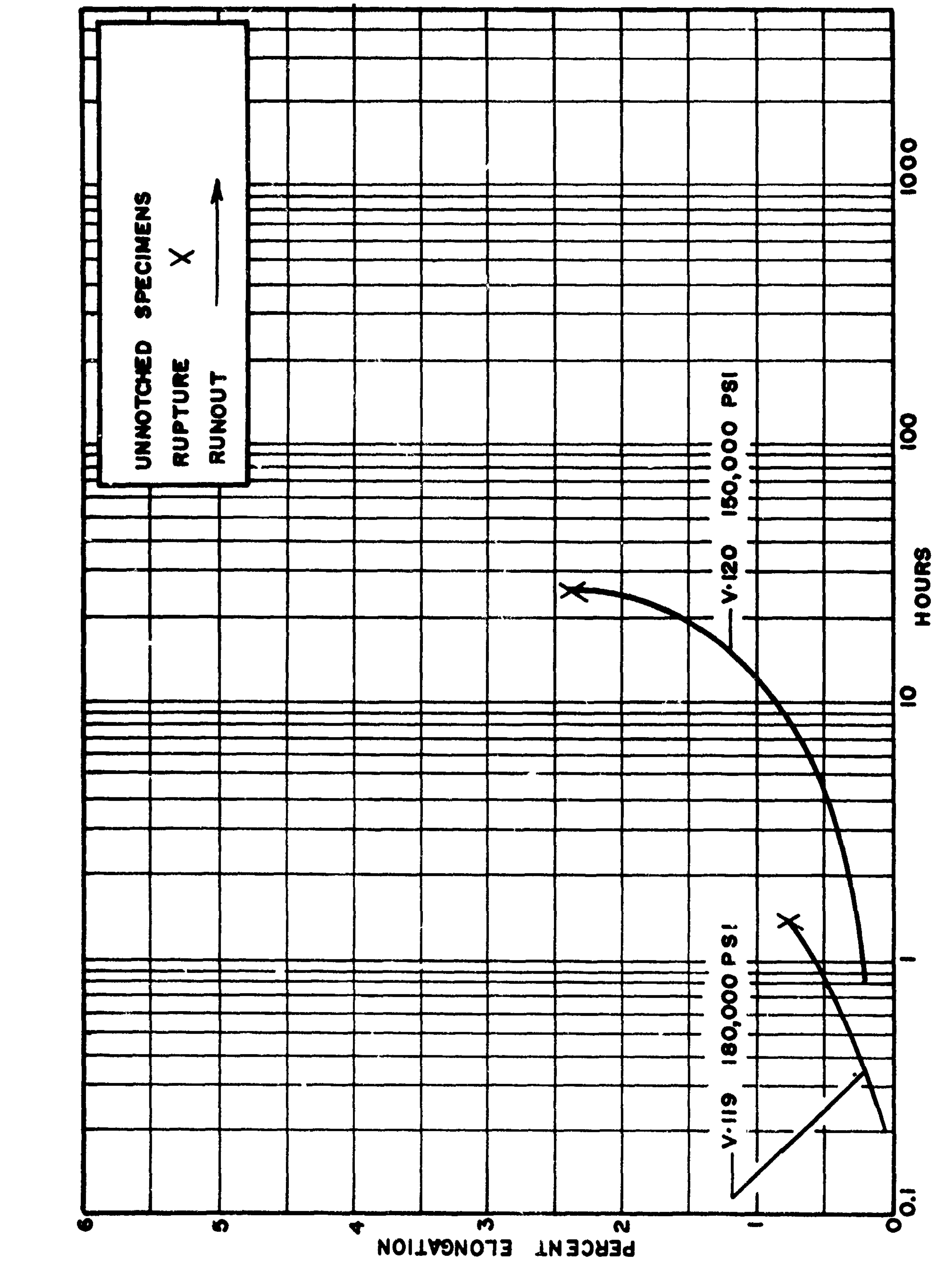


FIGURE 64 STATIC CREEP: VASCOJET, 1000°F

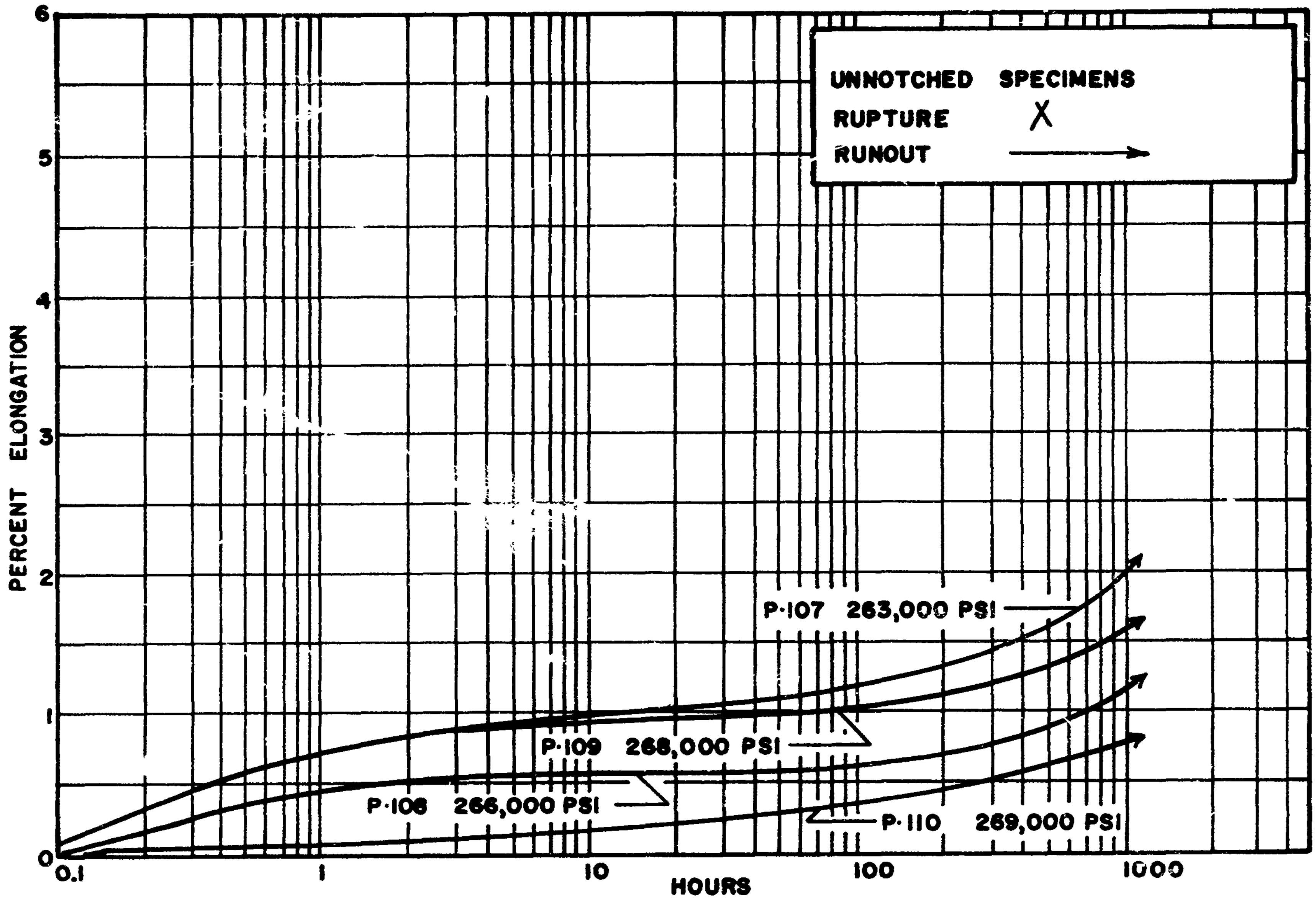


FIGURE 65 STATIC CREEP: PEERLESS 56, 550° F

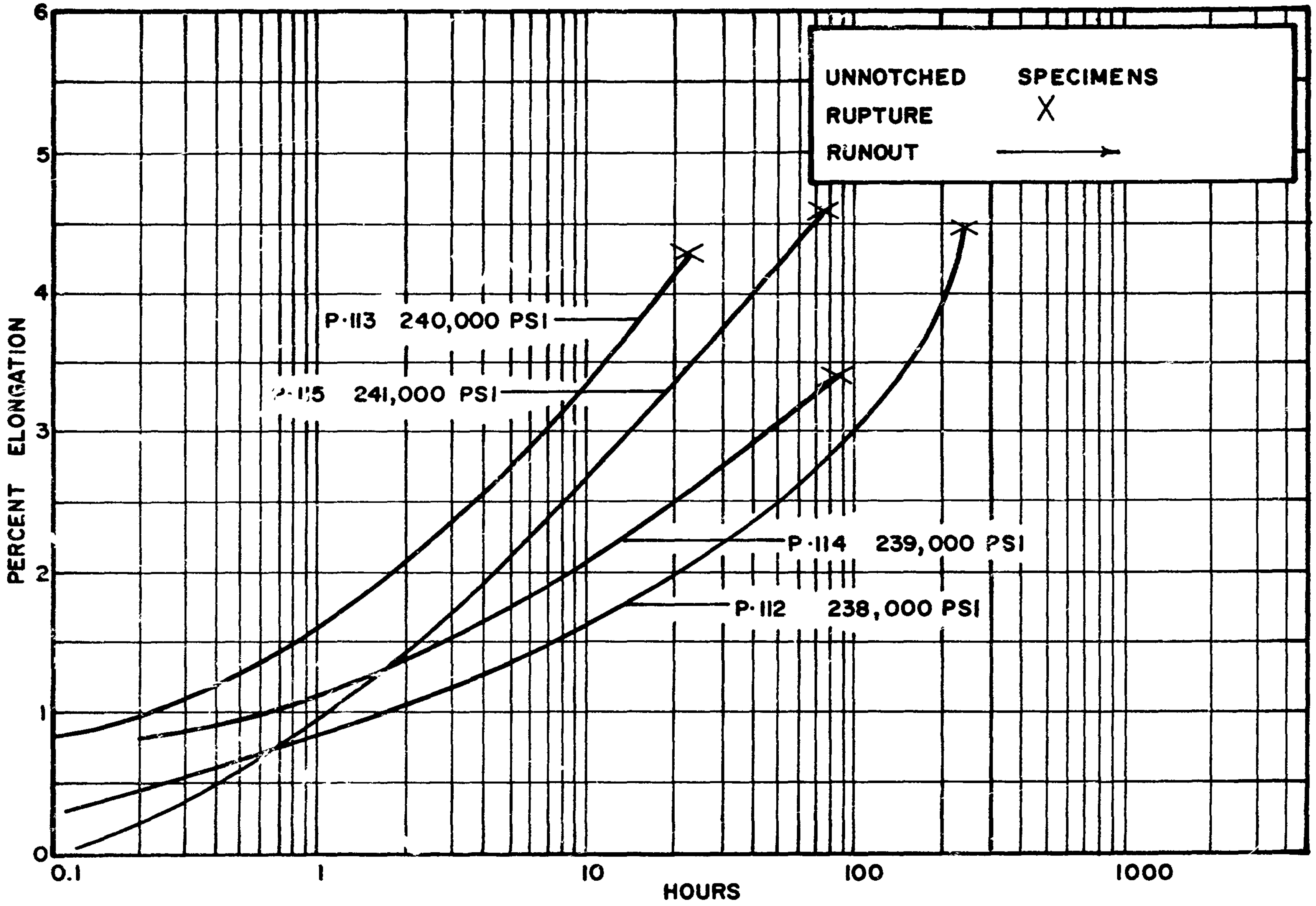


FIGURE 66 STATIC CREEP: PEERLESS 56, 800°F

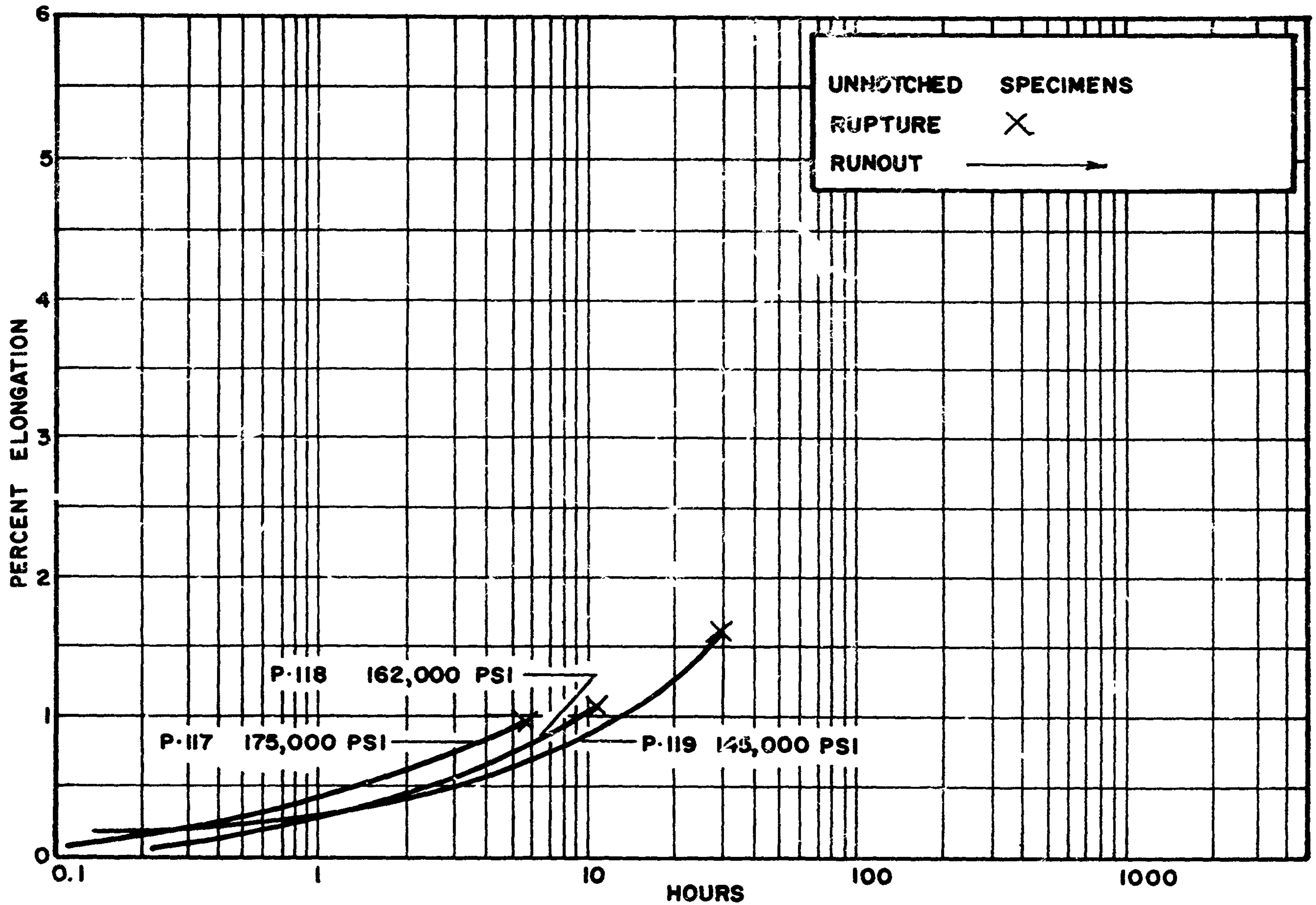


FIGURE 67 STATIC CREEP: PEERLESS 56, 1000°F

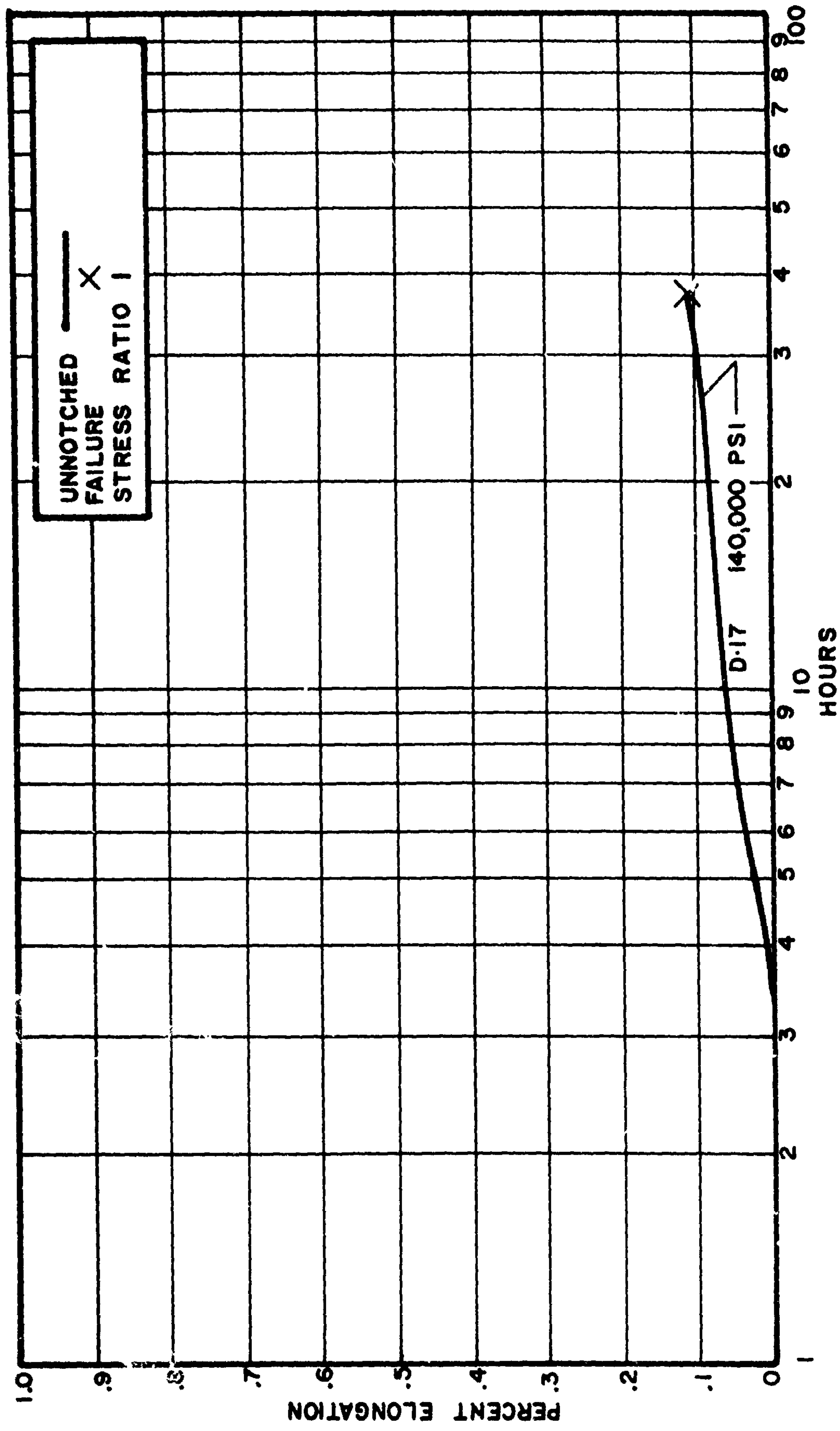


FIGURE 68 DYNAMIC CREEP: D6AC, 450° F

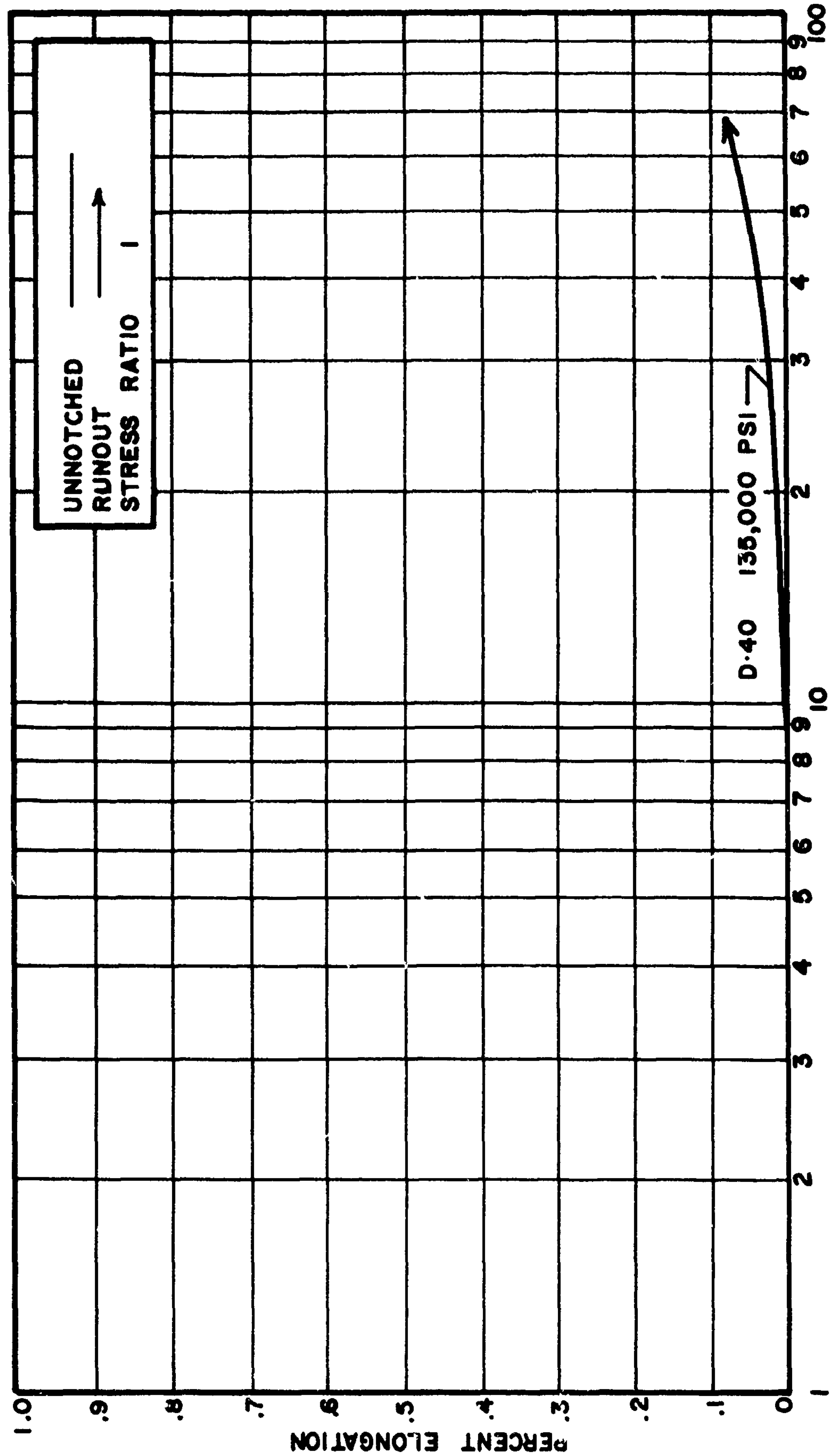


FIGURE 69 DYNAMIC CREEP: D6AC, 550° F

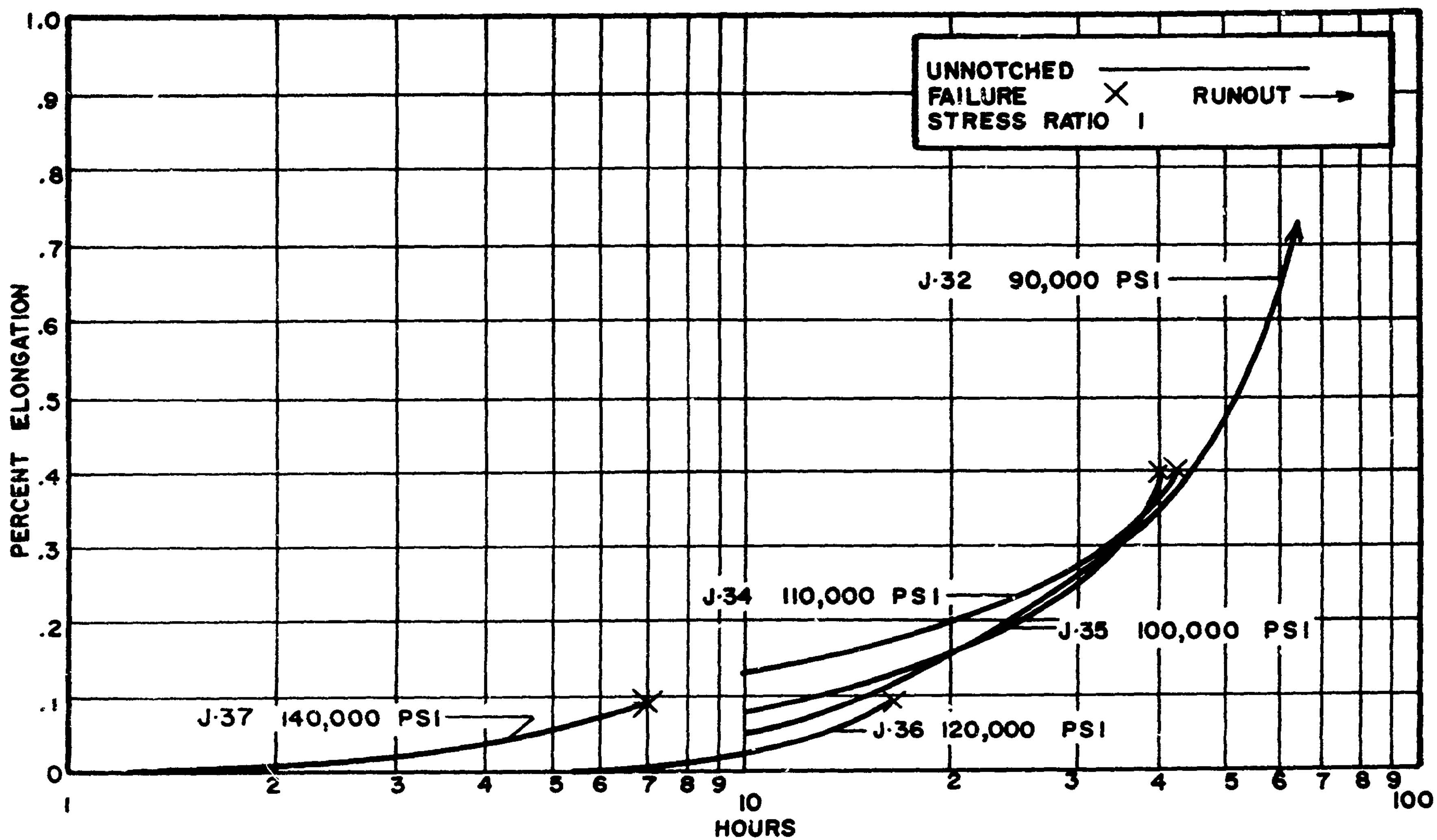


FIGURE 70 DYNAMIC CREEP: THERMOLD J, 1000° F

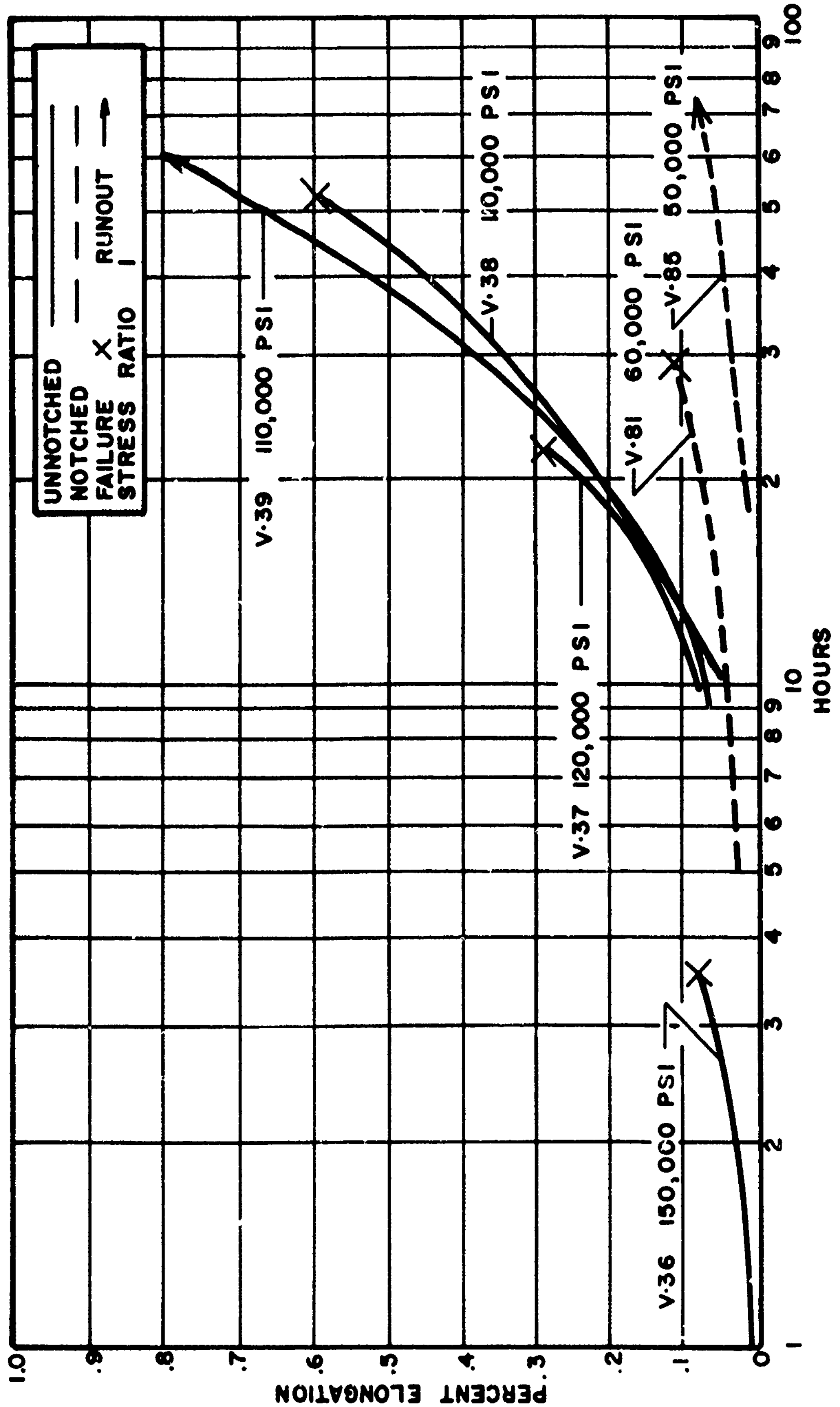


FIGURE 71 DYNAMIC CREEP: VASCOJET, 1000°F

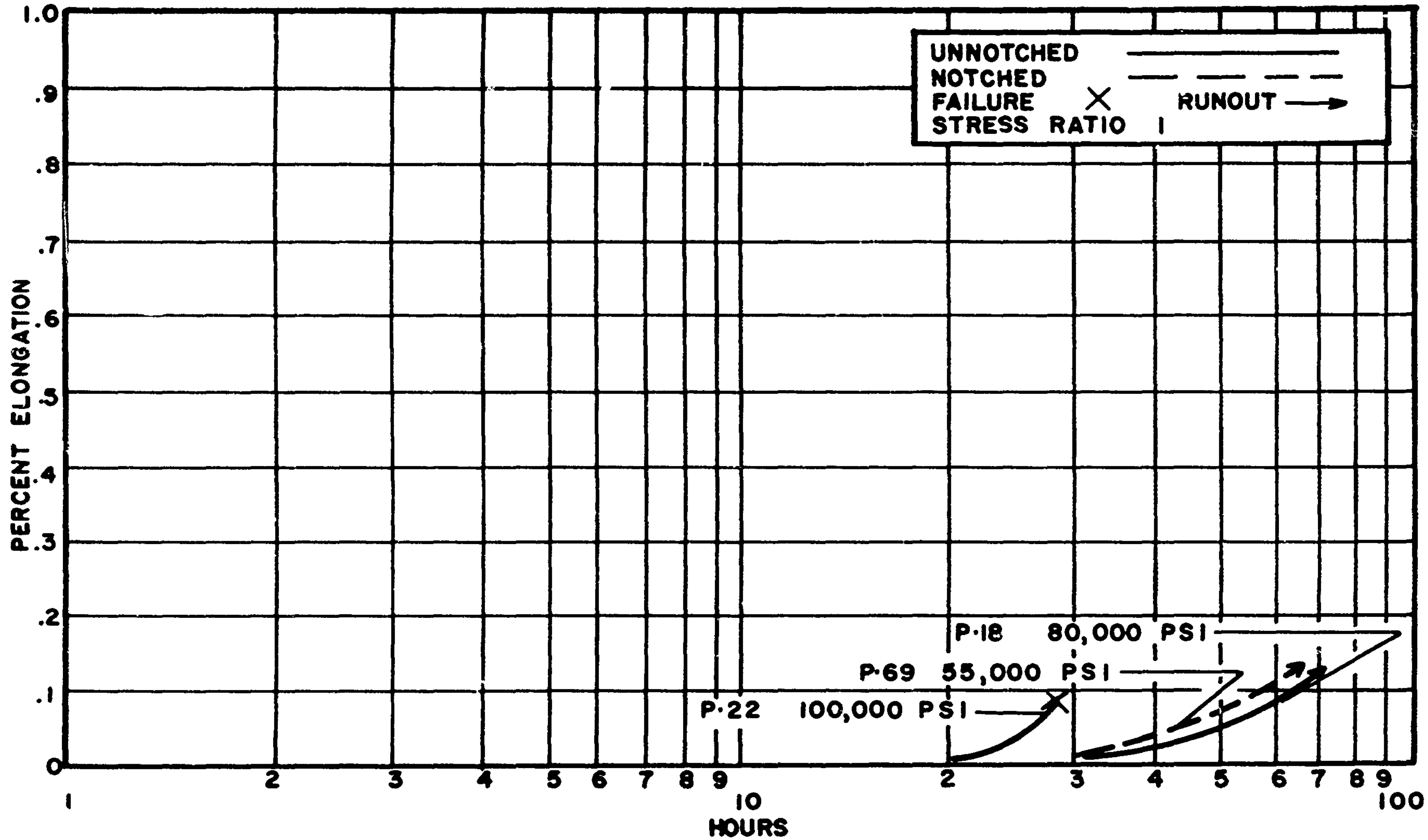


FIGURE 72 DYNAMIC CREEP: PEERLESS 56, 800°F

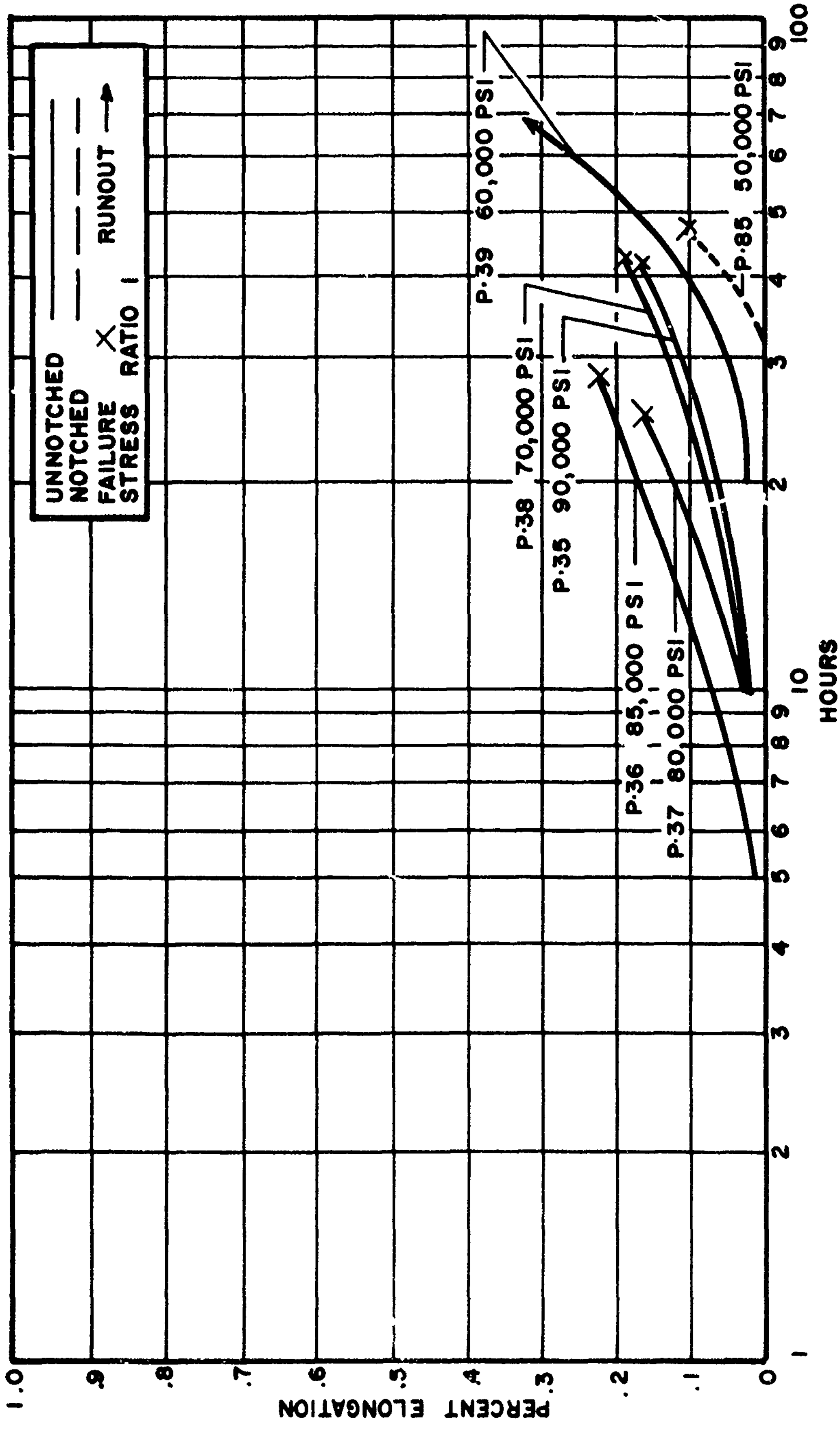


FIGURE 73 DYNAMIC CREEP: PEERLESS 56, 1000°F

Aeronautical Systems Division, Dir/Materials and Processes, Applications Lab, Wright-Patterson AFB, Ohio.
Rpt Nr ASD-TDR-62-480. FATIGUE AND DYNAMIC CREEP OF HIGH-STRENGTH STEELS. Summary report, Aug 62, 105pp incl illus., tables, 3 refs.

Unclassified Report

A program was conducted to obtain detailed tensile, stress rupture and fatigue data on a series of high-strength steels. Data were obtained from D6AC, LaBelle HT, Thermold J, Vascojet 1000 and Peerless 56, heat treated to nominal ultimate strength of 280,000 psi.

Tests were conducted at room temperature

(over)

and at elevated temperatures, the particular temperatures being selected according to the material. Maximum test temperature was 1000° F.

Dynamic creep data were obtained in conjunction with the fatigue tests.

1. Tensile fatigue
2. Rupture
3. Creep
I. AFSC Project 7381, Task 738103
II. Contract AF 33 (616)-6946
III. Lessells and Associates, Inc. Boston, Mass.
IV. R. F. Brodrick
V. Secondary Rpt. Nr Proj. 681/c48
VI. Aval fr OTS
VII. In ASTIA collection

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FOREWORD

This report was prepared by Lessells and Associates, Inc. under United States Air Force Contract No. AF33(616)-6946. This contract was conducted under Project No. 7381, "Materials Application," Task No. 738103, "Data Collection and Correlation." The work was administered under the direction of the Applications Laboratory, Directorate of Materials and Processes, Aeronautical Systems Division, with Mr. V. Lardenoit acting as project engineer.

This report covers work conducted from January 1960 to March 1962.

Personnel at Lessells and Associates, Inc. who contributed to the program were E. T. Booth, R. F. Brodrick, B. P. Friesecke and B. H. Schofield. The project is identified internally as Project No. 681/c48.

4-97C, 600, 9-24-62